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Erecting the Snake River Viaduct: O.-W. R.R. & Nav. Co.

By W. J. Howard*

The new Snake River cutoff of the Oregon-Washington R.R. & Navigation Co., between Hooper and Ayer, Wash., is a single-track line 17 miles long, which reduces the distance between Spokane and Walla Walla by 30 miles and reduces the grades so that the standard trainload can be increased from 30 cars to 40 loaded cars. This line was put in operation on Oct. 1, 1914.

The construction of the line presented many difficult problems. In the 14 miles from Hooper to the Snake River there are seven tunnels (three on a 6° curve) and four bridges. Three of the bridges cross the Palouse River, which the road follows for the first 14 miles, and which is a small stream in a cañon 50 to 150 ft. wide at the rim and 50 to 280 ft. deep. As the work reached a bridge site, the erection contractor built the bridge, allowing the construction outfit to cross the cañon and continue the work to the next bridge site.

The Snake River Viaduct, which is the last and longest of the bridges, is an important structure, 3920 ft. long, with a maximum height of 300 ft. above the water.

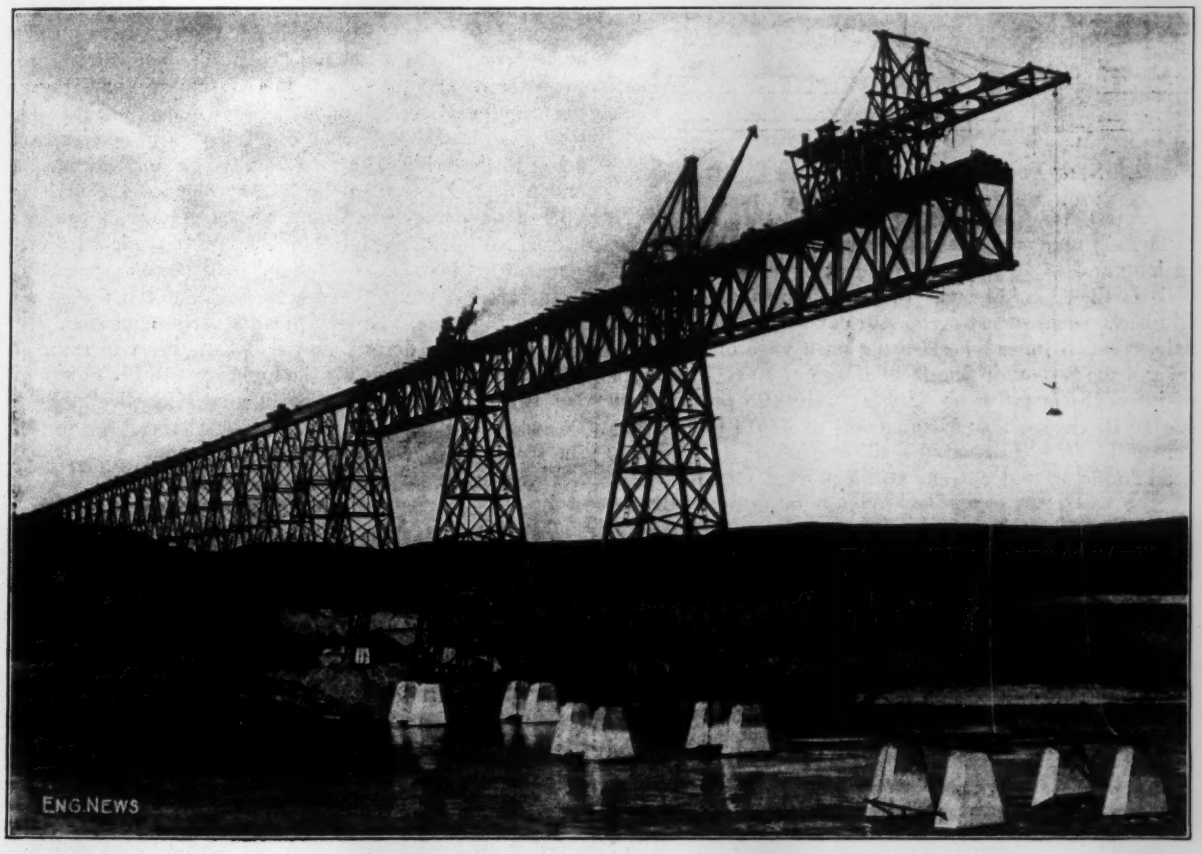

Fig. 1. Cantilever Erection of the 246-Ft. Truss Span of the Snake River Viaduct: O.-W. R.R. & Nav. Co. (300 Ft. above the Water)

(This shows the traveler, the large derrick car and the small derrick car. This last, with a dinky locomotive, delivered material from the bridge yard. On the river bank may be seen the pedestals and base of the temporary steel tower used at the middle of the first truss span.)

It is composed as follows: Five 60-ft. and eighteen 80-ft. deck-girder spans, three riveted-truss deck spans of 226 ft., one of 206 ft. and one of 246 ft. This last was over the low-water channel and was the center one of the five truss spans.

Erection of the East Viaduct Approach

The erection beginning at the Hooper (or Spokane) end consisted of three 60-ft. and fifteen 80-ft. deck-girder spans, and 18 four-post towers with their 40-ft. girder

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caps. The height of the towers increased from 35 to 180 ft. The erection of this approach to the truss spans was started Feb. 18, 1913, and completed May 26, 1913. Fig. 1 shows the truss spans under erection and the viaduct approach completed at the Spokane end.

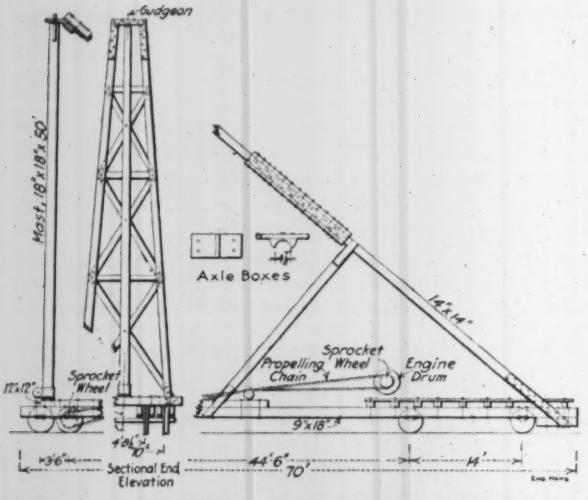


FIG. 2. SELF-PROPELLING DERRICK CAR FOR THE ERECTION OF THE SNAKE RIVER VIADUCT

The rig used was a "mule" traveler or derrick car 70 ft. long and 12 ft. wide, with a deck of 9x18-in. timbers. This is shown in Fig. 2. It was mounted on four sets of wheels, each consisting of four car-wheels on a 4¾-in. axle, the two inner wheels being on a gage of 4 ft. 8½ in. and the two outer wheels on a gage of 10 ft. Two sets of idler wheels (with no flanges) were also provided on the 10-ft. gage. The A-frame was of 14x14-in. timbers spread 11 ft. c. to c. at the sill and about 4 ft. at the head frame or spider. The stiff-legs were 14x14-in. timbers, spliced, their lower ends bolted to the deck, behind the engine, and their upper ends bolted to the gooseneck plates. The mast was a 50-ft. timber 18x18 in., with its foot set in a standard derrick shoe and its head having a 5-in. gudgeon pin fitted to a hole in the spider, which was built of channels and plates. The boom was a 72-ft. timber 16x16 in., trussed on four sides with 4x12-in. timbers blocked out at the center and quarter points. It was swung by lines led to a niggerhead on the engine.

This rig was built on the ground from timbers that were at hand, which accounts for its ungainly appearance. The hoisting engine had cylinders 8¼x10 in., and the first of its three drums was replaced by a split sprocket wheel placed on the drum shaft. A similar sprocket wheel was placed on the axle of the second set of wheels under the front end of the derrick car. These wheels were connected by a 1-in. chain, and in this way the rig was made self-propelling.

The steel for this east approach viaduct was unloaded at Hooper, the yard at the bridge site not being ready to receive it and the foundation contractors requiring all the car space available for their own equipment. The steel was loaded as required by the yard derrick, and taken to the bridge site by a "dinky" or small locomotive and a derrick car, and the latter unloaded the material upon a temporary platform. The large derrick car then backed up to the platform (about 200 ft.), picked up the steel, ran it forward and erected it in place.

In the first place, the nearest bent for the towers was erected complete, then the girders of the end span were placed, and the derrick moved out on them to complete the tower. The bents for the higher towers, or those having two or more sections, were guyed longitudinally at the column splices before the car moved ahead to complete the tower.

It was necessary to outhaul the columns of the first

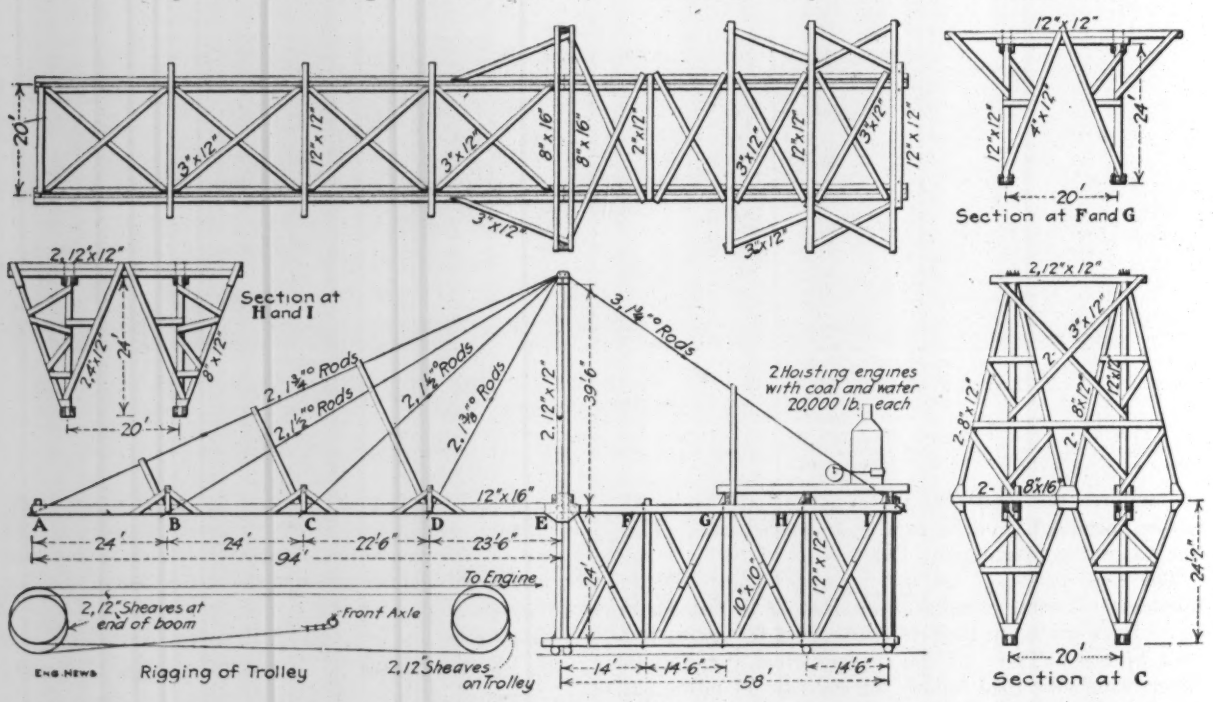


FIG. 3. TRAVELER FOR ERECTING THE TRUSS SPANS OF THE SNAKE RIVER VIADUCT: O.-W. R.R. & NAV. CO.

bent of each tower in the 80-ft. spans, the longest outhaul being 21 ft. However, this gave no trouble as there was plenty of drift or leeway.

After the erection of this approach the work was delayed until December, 1913, on account of changes in the plans and by shop delays.

Erection of the Truss Spans

The truss spans were erected as cantilevers, except that the first span had a temporary tower at mid-length. In December, 1913, the erecting contractor started to frame the traveler shown in the accompanying Fig. 3, this is shown also in the view, Fig. 1. The traveler had two 94-ft. horizontal booms for trolleys; these were spaced 20 ft. c. to c., which was the spacing of the top chords of the spans. It was framed and assembled on shore before being erected in place on the completed half of the first 226-ft. truss span.

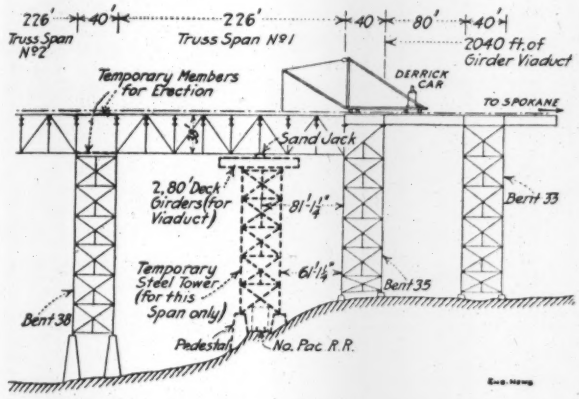


Fig. 4. Temporary Tower Used to Support the First Half of the First Truss Span

This part of the truss span had been erected with its shore end on its permanent tower. The outer end was supported by a temporary tower, as shown in Fig. 4. This tower was composed of parts of one of the river towers capped with two 27-ton 80-ft. girders for the first girder span next to the truss spans at the opposite end of the bridge. These girders were specially designed and made about 7 tons heavier than the rest of the 80-ft. girders, for the purpose of using them to cap the temporary tower and support the projecting end of the truss span. They were the heaviest single pieces handled, with the exception of the 31-ton erecting devices. The temporary tower was erected by the big "mule" derrick car (Fig. 2).

This first half of the first truss span was supported at panel-points L5 by two shoe castings for one of the river towers. These castings rested upon the 58-in. wood plungers of the sand jacks shown in Fig. 5, these jacks resting upon the upper grillage. The lower grillage spanned the two 80-ft. girders. The temporary tower had concrete pedestals similar to those for the permanent towers. It spanned the line of the Northern Pacific R.R. along the river bank, and the bracing of the lower panels of its sides had to be designed to lie outside of the clearance limits for trains, as indicated in Fig. 4. It was 40x68 ft. at the base, and the diagonal bracing in the bottom panels was of 12x12-in. timbers.

This half span being in place, the traveler was erected upon it and finished the other half of the span as a cantilever. The permanent tower was then erected beneath the end of the span, and the trusses lowered upon it by means of the sand jacks. The plungers of these jacks, composed of 12x12-in. fir timbers, had crushed down more than was expected during the erection of the span, and there was barely ½ in. to spare in placing the shoes for the truss seats. The jacks were intended to provide 2-in. clearance, and designed for a load of 350 lb. per sq.in. on the sand.

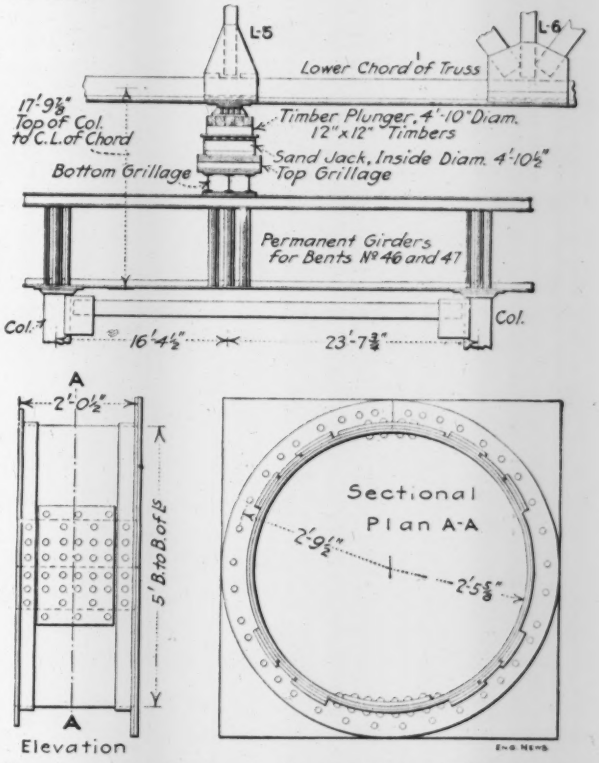


Fig. 5. Sand Jacks for Lowering the First Truss Span to Rest on Its Outer Tower

(The sand jacks were on the temporary tower, as shown in Fig. 4.)

The erecting device used to hold or anchor the cantilever for the other spans consisted of the usual compression members butting against the ends of the bottom chords and tension members pinned to the top chords of the previous span, as shown in Figs. 1 and 4. A wedge between two pins at the center of the tension members allowed the necessary adjustment for erection and for lowering the span upon the tower when completed. The wedge was operated by a screw by men standing on a platform slung below this temporary member. It was operated from beneath instead of from above in order to allow clearance for the traveler in passing over it.

The steel for the truss spans and the west approach was unloaded at the bridge site, and as required it was loaded upon car trucks or buggies and run out to the traveler by the dinky engine. The towers for the truss spans were erected complete under the spans before lowering the latter upon them. It was necessary to outhaul the lower columns, and this was done by means of a runner line at the end of a timber outrigger bolted to one end of the piers, as shown in Fig. 6. With over 200 ft. of drift this worked very well for the bottom section.

The middle sections were closer in, but as there was a corresponding decrease in the amount of drift the erection of both sections was equally difficult.

Erection of the West Viaduct Approach

At the Ayer or west end of the bridge, the two 60-ft. girder spans and the first of the three 80-ft. spans were erected (starting at the shore end) by a derrick car with a 52-ft. boom.

A special feature of the work was that the first bent of the tower for the 80-ft. span was assembled in an inclined position. This bent was 113 ft. high. It stood at an angle of about 60°, leaning against two timber bents fixed to the next tower. The lower end of one leg was in such position that it would engage the anchor bolts in the base plate when the bent was tipped into position. The other leg being about 6 ft. shorter (and the whole bent being on a 6° curve) was blocked up about 10 ft. in

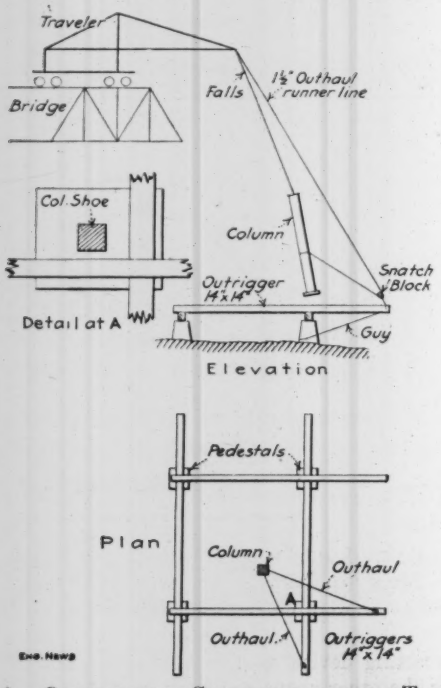


Fig. 6. Outhauling Columns for the Towers of the Truss Spans

from the pedestal and 6 in. higher than the tips of the anchor bolts; rails were placed under the base plates of the leg to make it easier to slide it into place when tipped to the perpendicular position.

This placed the bent in a good position for tipping it into place, and also brought the legs within the reach of the 52-ft. boom of the derrick car. The two lower columns of the bent had to be outhauled, however. The position of this bent and the arrangements for its erection are shown in Fig. 7.

The derrick falls were hooked to the bent on the under side (or inner side) and a 5-part 1½-in. tackle was run out ahead to a pennant line attached to one of the completed towers and back to a niggerhead on the engine of the derrick car. The 113-ft. bent, weighing 35 tons assembled, was then tipped to an upright position, the 1½-in. fall line taking the load when the derrick-car falls had passed the length of the boom.

The bent was then guyed and jacked into place, and lowered over the anchor bolts. This bent as erected had all of the transverse struts in place, but none of the bracing. The column splices and struts were 75% bolted.

The remaining two 80-ft. spans (which included the two 27-ton girders used on the temporary tower already

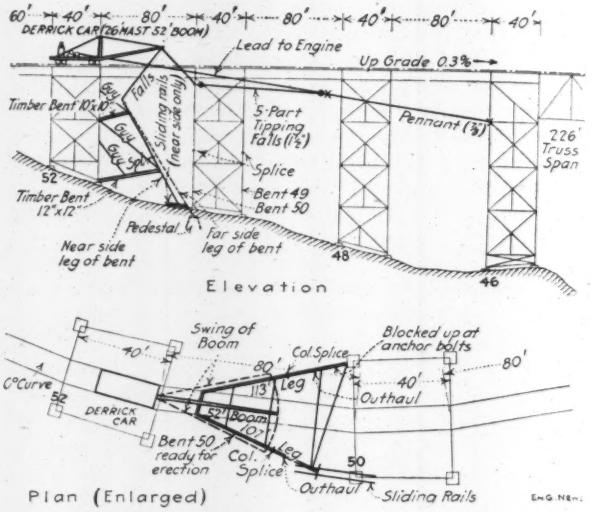


Fig. 7. Method of Erecting Bent No. 50 of the West Approach Viaduct

(The bent was assembled in the inclined position and then raised to its vertical position on the pedestal.)

described) were erected from the end of the truss spans of the bridge by means of the large derrick car which had erected these spans. One tower was also erected by this car. The car could not pass the 6° curve at this end of the bridge, and for this reason the smaller derrick car had to be used (working from the west) on the end girder spans.

The steel for this curved portion at the extreme west end of the bridge was reloaded at the bridge yard and shipped 56 miles to reach the west end for erection.

Engineers and Contractors

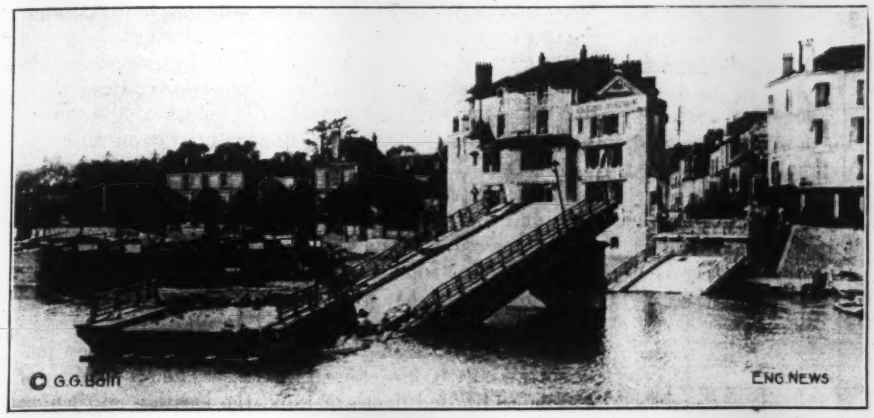
The design and construction of the bridge were under the direction of J. R. Holman, Chief Engineer of the Oregon-Washington R.R. & Navigation Co., and C. B. Moore was engineer in charge. The steelwork was built by the American Bridge Co. (Gary plant). The Missouri Valley Bridge & Iron Works, of Leavenworth, Kan., had the contract for the piers and substructure. The Kelly-Atkinson Construction Co., of Chicago, had the contract for the steel erection, and its force averaged 60 men. The total weight of steel erected was about 8100 tons.

Valuable Information on an Accident Report Blank—On the Baltimore & Ohio R.R., where an accident occurs to an employee, the foreman under whom the employee is working must fill out and send in to headquarters an accident report blank. The Chicago "Tribune" says that while a gang of carpenters were at work on a bridge over the Chicago River, one of them missed his footing and fell in. The foreman filled out the accident blank and opposite the question "What does the injured person say?" he wrote, "He says it was a damn good thing he could swim."

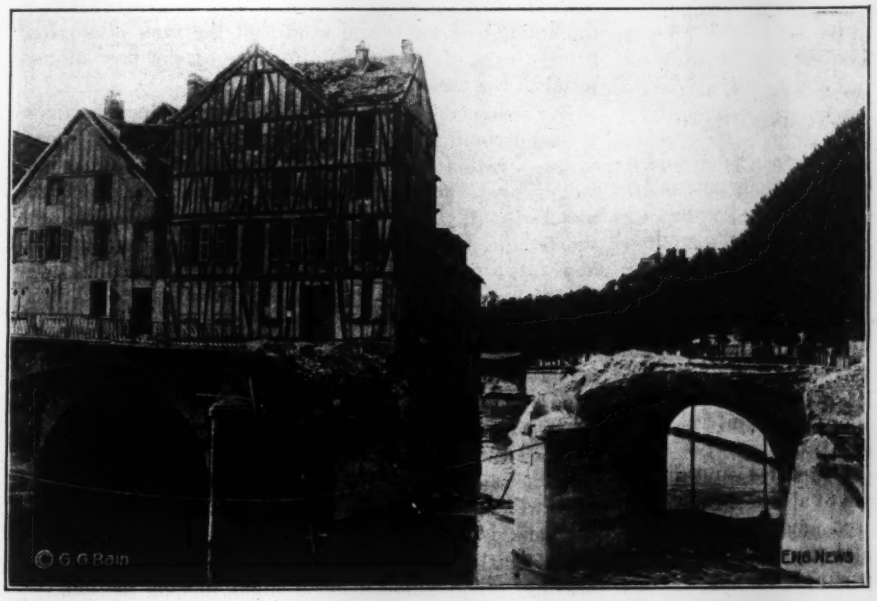
Bridge Destruction in the European War

An army in retreat always endeavors to protect itself against the pursuing forces of the enemy by destroying the bridges in its rear, tearing up railroad tracks, burning rolling stock, etc. Some idea of the destruction effected in the zone of active military operations in Europe during the past three months is shown in the accompanying views.

It is a part of the duty of engineer troops in warfare to destroy the bridges in the rear as the army retreats, usually by exploding dynamite at the base of its piers, or, in case of masonry arches, at the haunch of the arch or the springing line. The duty of the engineer force with the pursuing army is to replace the gap as rapidly as possible by rapidly constructed pile or pontoon bridges. The photographs bring to mind the vast amount of new construction that will be required at the conclusion of the war to restore to normal conditions the avenues of transport and communication.



Destruction of a Girder Bridge at Lagny



Wreck of a Masonry Arch Bridge at Meaux

The Electric Precipitation of Tar Vapors from Gas

An interesting development of (or rather a departure from) the Cottrell process for the precipitation of suspended matter in gases (see Engineering News, Oct. 26, 1911, and Oct. 9, 1913) was described by F. W. Steere, of Detroit, before the American Gas Institute in New York, Oct. 22, 1914. The author, while engaged in research work at the University of Michigan upon the electrical separation of tar from gas, found that high-tension alternating current might be used instead of the rectified high-tension used by Cottrell. The gas to be purified is led through a pipe and the high-tension current discharged between a central electrode and the walls during passage. The gas is ionized and the resulting tendency to recombination of the dissociated atoms results in an agglomeration of the dense tar mist into relatively few and large tar drops. The larger tar particles can easily be freed after the gas has left the electrical chamber by passing through a centrifugal tar extractor, etc.

A plant having a capacity of about 30,000 cu.ft. of gas per hour was built at the Detroit coke ovens. Gas was taken from the hydraulic main, passed through a small washer cooler, and led through the ionizing tube from which it went to a spiral tar extractor and exhauster, a washer cooler and a Venturi meter leading to the main. In some 1200 tests, by aspirating a given quantity of gas through two thicknesses of filter paper, practically white papers were secured. All work was done on the rich gas given out during the first six or eight hours of the coking period of the recovery oven, Best results were obtained with gas entering the ionizer at from 65° to 80° C. It was found that the naphthalene crystals were freed after the tar was extracted, so that they were recovered clean and white.

With the aid of Edward Gray, Chief Engineer of the Ford Motor Co., a cleaning plant was built for the producer gas used in the large gas engines of this company. This plant has been in continuous and successful service for several months, has required no special attention, is self-cleaning, and is stopped and started by the regular employees.

Operation of Sand and Gravel Plants

By W. H. Wilms*

SYNOPSIS—A continuation of article in Engineering News, *Nov. 12, covering crushing, storage and power plant in sand and gravel plants.*

Preparation of Sand

Grades—Two grades of sand are generally produced, a coarse sand for concrete and a fine sand for plastering and brickwork, often called building sand. The manner of preparation depends upon the character of the sand, the size and graduation of the bank-run material, and its specific gravity.

Coarse sand, or torpedo as it is called in the Middle West, is a sand running from ¼ in. down to fine sand, the graduation being uniform. An analysis of a good grade of torpedo sand is given (Fig. 1).

Separation of Grades—It is often the case that the sand contained in a gravel deposit is a well graduated, coarse sand and in such cases all that is necessary is to

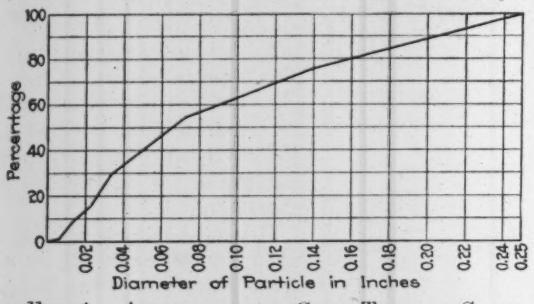


Fig. 1. Analysis of a Good Torpedo Sand

screen it through a ¼-in. or ⅜-in. screen (depending upon how coarse the sand is desired), and then take it directly to a settling tank to remove the dirt and water. In many instances, however, the bank sand is poorly graded, containing an excess of very fine sand, which must be removed before a well graded material can be obtained. This is done in several ways, depending upon the amount of the excess fine sand which must be taken out, the amount of water present, and the specific gravity of the sand.

Figs. 2, 3 and 4 show three methods commonly used to effect the removal of the fine sand. In Fig. 2 the sand coming through the perforations of the coarse sand screen is permitted to flow over a fine screen of about ⅛- to $\frac{3}{16}$-in. mesh, which screens out any desired amount of the fine material by regulating the feed and the supply of clean water to the screen, an insufficient supply having a tendency to clog up the perforations, thus permitting a part of the fine material to run over with the coarse.

In Fig. 3 the excess of fine sand is taken out by means of a second settling tank. This method works very well where the fine sand has a comparatively low specific gravity, such as quicksand. Regulation here is obtained by raising or lowering the flashboard *B*, in Fig. 3; by lowering this board the amount of fine sand flowing to the second settling tank is reduced, while raising it increases the amount of fine sand going over. A screen of small mesh is placed at the overflow of the first settling tank to prevent any large light particles from flowing over with the fine sand.

Fig. 4 illustrates a method now quite extensively used. The coarse and fine sand in flowing from the initial sand screen is made to pass over a small-mesh screen placed in the bottom of the trough or chute leading to the settling tank. Directly underneath this screen is a second tank. The screen takes out the fine material, separation of the dirt and water being effected by the settling tank directly underneath. Regulation is obtained by means of a sliding plate placed over the screen; this plate shortens or lengthens the length of the screen, thus regulating the amount of fine material going through.

Settling Tank—The settling tank is one of the most important parts of a washing and screening plant. A poor one will spoil material in the bins about as fast as it is prepared. While there are a number of patented sand separators on the market, the ordinary tilting settling tank (Fig. 5), when properly made and regulated will produce entirely satisfactory results.

The correct design of a settling tank for a given material can only be ascertained by trial. The proportions of length, width and depth of tank, the location and length of outlet pipe, the location of the supporting shaft and counterbalancing, all depend for their determination upon the nature of the sand, its weight and behavior in water, the amount of water and sand that the tank is required to take care of, and the uniformity of the flow of material to the tank.

For instance, the longer the discharge pipe, the dryer the sand coming from the tank. This is due, of course, to the greater and more effective seal formed by the longer pipe. There is a limit, however, at which the material will fail to discharge at all. Likewise, the shorter the pipe the wetter the sand discharged. Usually, however, a discharge pipe having a length equal to twice the diameter of the pipe will prove satisfactory. Six- and eight-inch pipes are ordinarily used.

With a given material and a uniform feed to the tank, a tank can be designed and constructed that will have a practically uniform discharge of material. The trouble experienced with poorly designed settling tanks is their constant tendency to let through the dirty water with the sand. It should be remembered, however, that no tank will operate satisfactorily if the flow of material to the tank is not uniform.

The settling tank is supported by a shaft having two bearings, upon which it has a slight rocking motion (see Fig. 5). The tank is counterbalanced at the rear with heavy weights. The valve opening in front is held against rubber-faced stops on a cross-timber.

The tank fills full of soil water, which runs off at the spillway at the top of the front. The sand quickly settles to the bottom of the tank, and when it accumulates enough weight it causes the tank to tip forward drawing the opening in front of the tank away from the rubber-faced stops, the sand running through the opening.

When a sufficient amount of sand has escaped, the reduction of weight of sand in the tank causes the tank to

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draw back against the valve-stop, closing the opening and stopping the flow. If the material comes into the tank uniformly, the tank will remain in a state of equilibrium, the outflow equaling the inflow. Thus the tank action is continuous and automatic. The very fine undesirable sand is carried away with the waste water.

The supporting shafts of settling tanks should not have journal bearings, for the friction, though slight, is too great for the very sensitive action required in the operation of the tank. Instead, knife-edge bearings should always be used.

Operating Difficulties—More trouble is generally experienced with the operation of the fine-sand tank than with the coarse. It is often a very difficult matter to get this tank to discharge properly, the tendency being for most of the fine sand to remain in the tank, only that portion immediately over the valve opening being discharged. When this happens the tank will frequently "spill" or let through the dirty water. It only takes a very few of such "spills" to ruin an entire bin of sand.

This trouble can often be cured and the tank made to discharge itself completely by providing a small discharge opening with valve stop, similar to the main discharge, near each side of the tank and about one-third its depth from the bottom. This will keep the sand in these dead quarters more or less agitated and prevent it from settling and becoming compact.

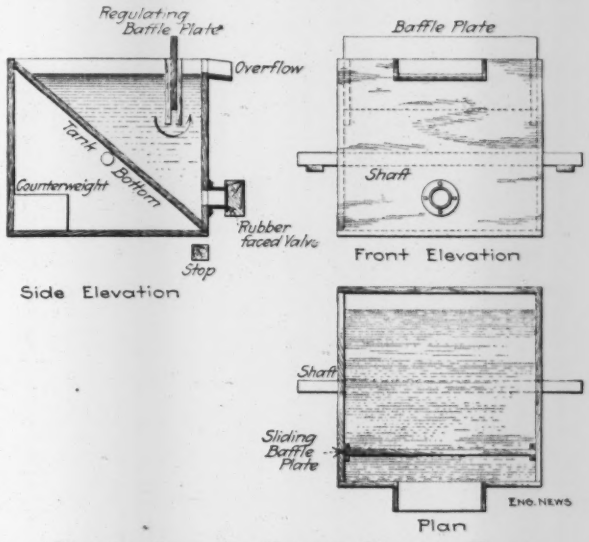


Fig. 5. Ordinary Tilting Settling Tank

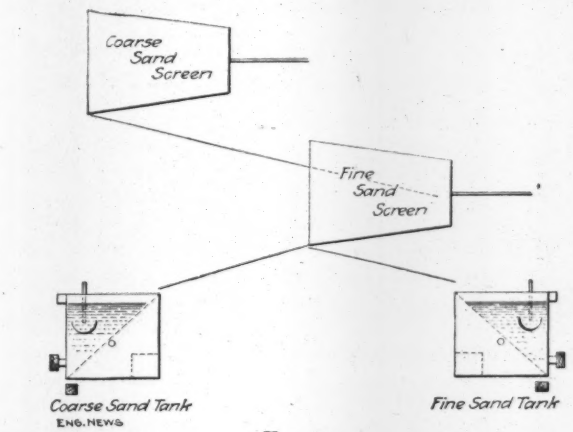


Fig. 2.

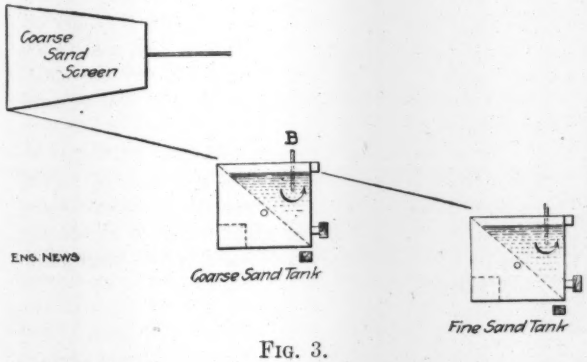


Fig. 3.

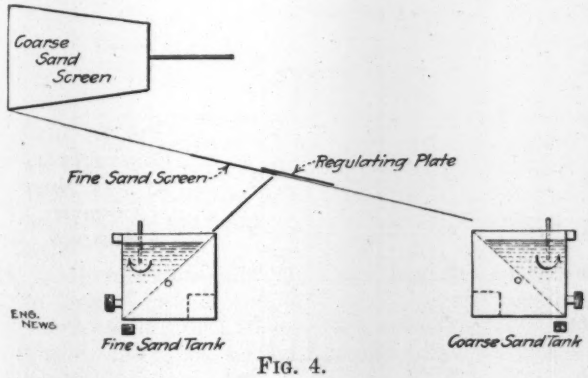


Fig. 4.

Figs. 2-4. Methods for Removing Fine Sand

Where the pit-run material is largely sand and the capacity of the plant a large one, some trouble is at times experienced with the automatic or tilting settling tank. Under such conditions a number of operators prefer stationary tanks, the discharge openings or valves being manually operated. Instead of one or two large openings, however, these tanks are provided with many small ones distributed around all four sides of the tank. The tank is made sufficiently large so as not to require the constant attendance of an operator, this work being usually performed by the man attending the "top."

Such tanks are usually made rectangular in shape instead of square as in the automatic or tilting tank, having a length of about twice the width and a depth of about one and one-half times the width. The valve openings are usually about 2 to 2½ in. in diameter.

A tank used especially in large ballast washing and screening plants is provided with conical discharge openings projecting from the bottom of the tank, the stop valves of these openings being operated from above by a small rack-and-pinion movement. These tanks are generally provided with two such openings, one being located near each end of the tank. The coarse sand is discharged from the opening near the head end of the tank and the fine sand from the other, separation being effected by the difference in the velocity of the water at the ends of the tank. While I have seen a fairly good sand produced by such a tank, the separation of the coarse from the fine sand is not as complete as it should be nor is the graduation everything to be desired.

Marketable Grades—In the preparation of a well

graded coarse sand, a large amount of fine building sand is often produced. Not all producers are so fortunately situated as to have a large market for this fine material, and many plants are now wasting it (which is generally an excellent building sand) for the want of a market. Under such conditions the cost of production of a well graded coarse sand is materially increased.

ing in a large percentage of over-size material or rejections going into the finished product.

Crushing—To produce a uniformly graded material means fine reduction—much finer than the maximum size being produced in a given material. Even where the product from an initial gyratory crusher is screened and the rejections delivered to a smaller secondary gyratory

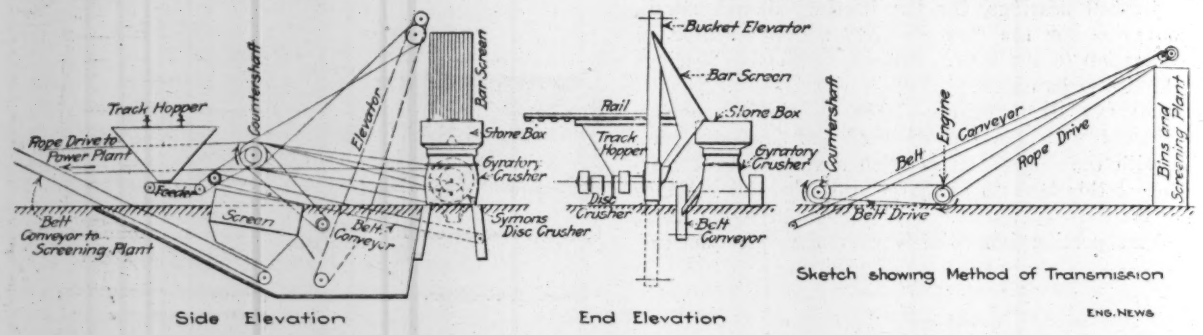


Fig. 6. Design for Initial Screening before Crushing Material

It may be mentioned here that this question of a market for all grades of sand the plant produces is a vital one to the producer. Quite often it means just the difference between success or failure of the enterprise. The importance of a complete and accurate knowledge of the market requirements and a thorough test and examination of the deposit cannot be too strongly emphasized to those who are contemplating going into this industry.

Crusher Equipment

From the writer's observation and experience the main point of weakness of many screening and washing plants is in their crushing and reduction equipment. It is here that an otherwise satisfactory material falls short of attainment—insufficient reduction. The material often has but one reduction through a gyratory crusher, resulting in a large percentage of over-size material or rejections going into the finished product.

Crushing—To produce a uniformly graded material means fine reduction—much finer than the maximum size being produced in a given material. Even where the product from an initial gyratory crusher is screened and the rejections delivered to a smaller secondary gyratory crusher for final reduction, the results are not everything to be desired. In the writer's opinion, the only effective solution of this reduction problem is the installation of a Symons disc crusher for final reduction, the initial breaking being performed by a gyratory. A majority of the largest and best plants in the country are now performing their reduction in this manner.

Location of Initial Screens—The top of the screening plant being generally at least 60 ft. high, it follows that the initial screening of the over-size material and its reduction should, if possible, be effected before the material is elevated to the top of the plant for screening and washing. Placing the initial screen on top of the plant and dropping the over-size material to crushers on the ground below and then re-elevating the rejections, is certainly not a very efficient method, to say the least. And yet, with few exceptions, this is the general practice.

There are a few modern, uptodate plants, however, that are performing this operation of initial screening and crushing before the material is elevated to the top of the plant. Fig. 6 shows the manner in which this is effected in two large modern plants.

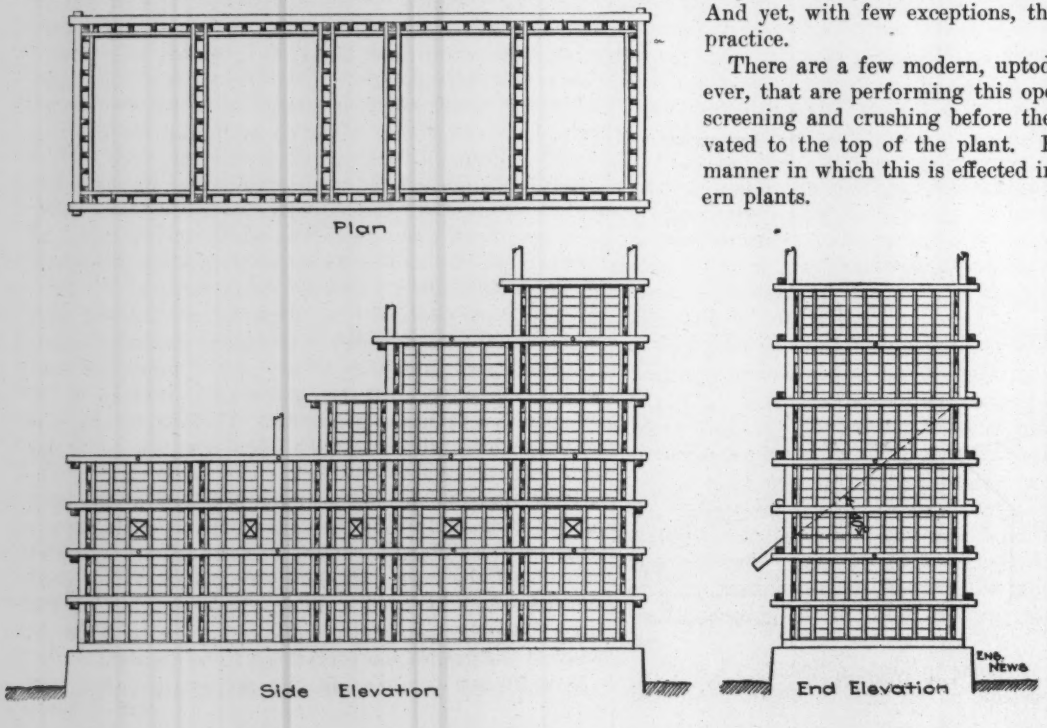


Fig. 7. Bin Construction by the Most Approved Methods

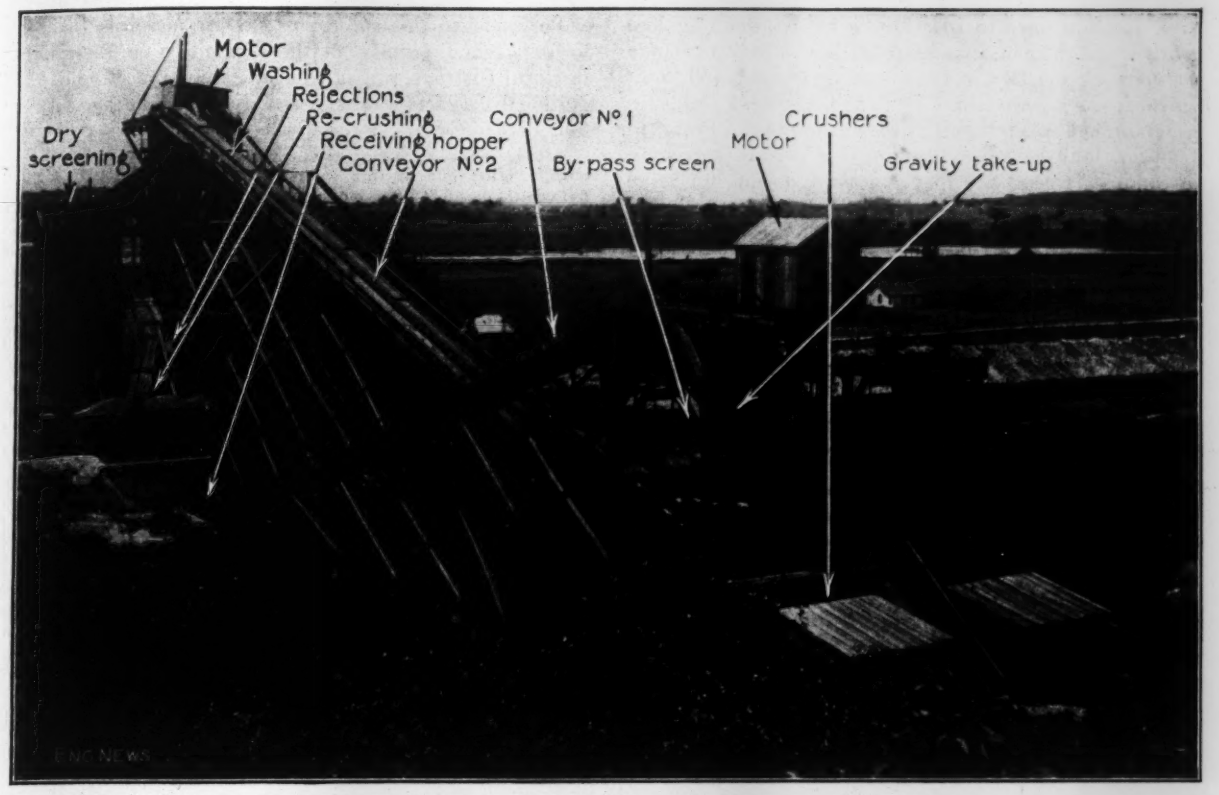


FIG. 8. PLANT OF THE CHICAGO SAND & GRAVEL CO.

ELEVATING AND CONVEYING

For elevating the material to the top of the plant the belt conveyor is almost universally regarded by operators as the best solution of the problem. Its slow and uniform feed to the screens, so necessary for effective screening, combined with large carrying capacity makes this method a very efficient one. While the initial cost and the cost of belt renewals exceeds that of a bucket elevator, the reduction in the amount of delays due to break-downs and repairs more than makes up for the difference.

In elevating the material to the top of the plant where the material is conveyed to the plant by cars discharging into a track hopper, the feasibility of using as heavy a grade as is practicable up to the hopper should be duly considered, thus reducing the height and length of the belt conveyor. Within certain limits it is more economical to elevate by cars and locomotive than by conveyor. Grades of tracks leading to the hopper, however, should not be excessive, 4% to 5% being considered a maximum.

STORAGE BINS

While storage bins are built of concrete and steel, the prevailing practice is to build them of timber. The bins are built up directly from the ground level, the space between the ground and bin gates being occupied by dead material; the wet material in the bins taking about a 40° slope (Fig. 7).

CONSTRUCTION—Bins of 14 to 20 ft. inside have proved to be the most economical under ordinary conditions. Greater widths than 20 ft. require extremely heavy cross-bracing and tying, making the construction an expensive one.

The old crib style of construction where the walls of the bin are built up of 2-in. plank laid and nailed together flatwise, has of late years given way to the form of construction shown in Fig. 7.

This design is not only somewhat more economical of lumber and labor of erection, but it possesses the additional advantage of easy and quick repairs. Repairs to bins built up of cribbing can be nothing more than patches. One of the main objections, however, to crib construction for sand and gravel bins is their extreme range of swelling and shrinkage in a vertical direction, due to the wet material in the bins. In a bin 35 to 45 ft. high this swelling and shrinkage often amounts to 5 or 6 in.

With the bearings carrying the screening and elevating machinery mounted directly on the top of such bins the results can better be imagined than described. In the frame type of construction the bearings are carried by an extension of the outside upright framing timbers which do not come in contact with the wet material.

Tunnel bins delivering material directly to cars underneath require extremely heavy masonry supports for the bin structure, and ordinarily are much more expensive for the same bin capacity than bins built directly upon the ground and filled up to the gate level with dead material.

CAPACITY—The capacity of bins necessary for a given daily yardage depends upon so many factors that no fixed rule can be given. The manner in which the plant is operated, extent and character of the switching facilities and service, the regularity in the supply of empty cars to the plant, whether or not open storage is practiced, all affect this question of bin capacity. Where there is a plentiful supply of empty cars but poor switching ser-

vice, it often pays to invest in a small switching locomotive rather than in additional bin capacity. Under ordinary circumstances, a bin capacity of from 450 to 600 cu.yd. is rarely exceeded, even in the largest of plants.

Loading Facilities—In order to produce a gravel for roadwork and concrete, containing a certain percentage of sand, it is necessary that at least one sand bin be adjacent to a gravel bin so that both the sand and gravel can feed out of the same spout into the car. If the sand and gravel are to be uniformly mixed, it must be effected while the materials are discharging into the car. In discharging sand and gravel already mixed in the bins, the gravel separates from the sand more or less, producing a very poor mix.

Storage—Closely connected with bin capacity is the question of open storage. It is here that practically every sand and gravel plant in the country is weak. The producer without provision for open storage is often compelled to sell his material at a loss, simply because he has no immediate market for it at the time it is produced. The demand for sand and gravel fluctuates more or less with activity in building and construction operations.

This wide range of fluctuation in demand causes the sand and gravel industry to operate under anything but favorable conditions, unless there is adequate provision

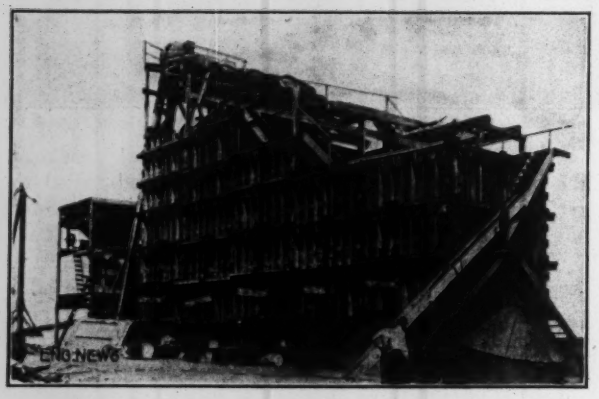


Fig. 9. Peoria Washed Sand & Gravel Co., Peoria, Ill.

for large open storage—a rare occurrence as yet in the industry. The empty-car situation, far from being perfect anywhere, helps to aggravate the situation. The increasing amount of winter concreting is also becoming an important factor in this question of open storage, dry screening being all that can be attempted during the winter months and this only under great difficulty and increased cost of production.

Power

There is no question of the economy of electric power for the operation of a screening and washing plant, where the same can be purchased at reasonable rates and without excessive primary charges. Due to the comparatively large number of units that must be driven and the comparatively great distances that often separate these units, the problem of transmission where steam power is used often becomes rather complicated and costly, both in first cost and maintenance. For these reasons, it often pays to use electric power with individual motor-driven units, even where the cost of same is somewhat above the ordinary.

Pertinent to this subject of electric power is the following from the report of the Committee on Electricity in Rural Districts, presented at the annual meeting of the National Electric Light Association, at Chicago, June 3-6, 1913:

> Motor drive and central-station service have been thoroughly tried out in this industry (sand and gravel). The flexibility of motor drive is of great value here. Putting individual motors on distant pumps and outlying belts dispenses with the operating troubles from long steam lines and long rope drives. On account of pumps being of considerable size and located several hundred feet from the screening plant, the use of 440-volt motors will in general be found desirable.
>
> The sand and gravel season closes as soon as the ground is frozen and plants shut down at dark, so that the load is strictly "off peak." Some attempt has been made to do dry screening in winter but with small success.
>
> A combination of individual and group drive will be found most advantageous in crusher plants, and the use of 440-volt motors will generally prove best. Crushers should be driven by slip-ring motors. If a crusher is shut down when it is full of rock it is often a troublesome job to clear it of all rock before starting up again. This is especially true if the crusher is driven by a squirrel-cage motor. If a slip-ring motor is used and the crusher belt is backed up a few feet by hand, the motor will often be able to start the crusher without its being necessary to clean out the rock. Dust-proof bearings should be used on all stone-plant motors, and it will usually pay to install all wiring in conduit.*

Steam power, however, will generally be the only form of power available to sand and gravel plants for a long time to come. The main problem here is to so concentrate the various units as to reduce the number of belt and rope drives and shafting to a minimum. Any method or means by which a belt, rope drive, shaft or gear can be eliminated is well worthy of consideration, for it is in the transmission that break-downs, delays, grief and trouble occur with too great a frequency for the peace of mind of the operator. Fig. 6 shows to what extent this problem of transmission has been solved in one particular case.

As a rule, the power-house equipment should be chosen for simplicity and rough handling rather than for economy and should consist of a plain slide valve or simple automatic engine, tubular boilers, heater, feed pump, etc. High-duty engines, water-tube boilers, and condensers have been installed, however, and this practice will undoubtedly be followed more and more as the industry develops.

Tests of Pipe Coatings as a Preventive of Electrolysis

Tests of "waterproof" coatings of iron and steel pipe have been made by the U. S. Bureau of Standards as a part of its broad investigations of the electrolysis problem and a report on the results has been issued in a bulletin (No. 15) by Burton McCollum and O. S. Peters. The materials which were used as surface coatings are as follows: (1) Paints which may be applied at ordinary temperatures and depend on oxidation, chemical action, or drying, for setting; (2) dips intended to be fluid at high temperatures—including asphalt, coal-tar, pitches, etc.; (3) wrappings consisting of alternate layers of cloth or paper and paints or dips; (4) fiber conduit in which the pipes can be laid, with or without pitch filling; (5) vitreous enamels; (6) portland-cement mortar and concrete coatings.

The last has been dismissed from further consider-

*For abstract of this report see "Engineering News," June 19, 1913, p. 1274.

ation by the Bureau, after calling attention to the fact that portland-cement mortar absorbs water readily and becomes a conductor of electricity at all times in damp soils. When the concrete is new, however, and contains much calcium hydroxide, there is an appreciable passivating action which allows current to leave a coated pipe without much corrosion of the iron; but, as the calcium hydroxide becomes converted to carbonate, this property is lost and the pipe corrodes rapidly.

The insulating properties of fiber conduits and vitreous enamels are still being investigated, and have not yet been reported on.

For studying the action of the paints, sheet-iron cones of about 7-in. base diameter and 1¾-in. altitude were used, coated on the interior. Four coats were usually found sufficient to give the best results of which any paint was capable, precaution being taken to secure perfect films.

The first test to which the painted specimens were subjected after the paint had dried was one for pinholes and flaws. The cone was filled with salt solution and 80 volts 60-cycle alternating potential applied for 30 sec. If no deflection of the galvanometer needle occurred, the coating was considered perfect. Specimens failing this test were rejected until a set of five perfect specimens was obtained for each paint. The effects of length of drying period were evident; the percentage of defective coatings tested at the end of ten days' drying was four or five times as great as at the end of two months' drying.

In the final test, each cone was filled to ½ in. from the rim with tap water or some electrolyte and placed in a rack. Two cones from each set of five were connected up with the sheet iron as anode and a bare copper wire, dipping into the water, as cathode. A third cone was connected in reverse order. A constant potential of four volts was impressed on the circuit leading to the paint films. Once in about two weeks the water would be completely evaporated from the cones and they would be refilled. This was desirable, to give alternate wetting and air exposure. The first appearance of current flow across the paint film was noted as failure, but the specimens were left in circuit until rupture was complete. There were 32 different paints, covering most of the widely advertised compounds, though not all (no so called "Bitumastic" products).

The general results showed that none was to be heavily relied upon to preserve its insulating barrier. Some lasted only a few hours, others a few thousand. Here and there, certain individual specimens withstood the action longer than others, even of their own makes. In one particular case ("Carbonkote" Interior) only one of the four specimens failed in a year of exposure. The data for each specimen indicate that the voltage had no appreciable effect toward reducing the length of service, which seems to depend upon the properties of the individual samples and the action of the water. However, the manner of failure of the coatings was distinctive of the direction of flow. Where the current was from iron to water, little rust spots appeared which grew to craters or bubbles; removal of a crater bubble revealed a pit filled with rust. Where the flow was from water to iron, no rusting of iron occurred, but gas was liberated under the film and lifted the latter until a blister was formed which left a large area of iron unprotected. Specimens to which no voltage had been applied showed no deterioration visible to the eye, in most cases, though they would permit current to flow.

Tests of fibrous pipe wrapping were carried out in much the same way. Sheet-iron cones were used, lined with alternate layers of dip or paint and paper or fabric. Four specimens were made for each test. These were set up in a rack, as previously described and filled with tap water. Two were set up with the iron positive, and two with the iron negative; a potential of 15 volts was employed. A few cones which were merely dipped were subjected to only four volts. There were 33 samples employing some 14 different compounds with various combinations of wrappings. At the time the report was made 82% of the total specimens had failed in periods varying from 7000 to 14,000 hours. On the remaining cones, the tests were still incomplete.

The results do not indicate that a life of such coatings as an insulating barrier can be expected to be more than two or three years and, in most of the cases, failure may be expected within a few months. The manner of failure was very similar to those of the paint coatings. The rupture of the coatings, however, was slower than with the paint after the first appearance of electrical breakdown—probably due to the thickness and rigidity of the coatings.

To avoid criticisms that the studies did not reproduce practical conditions, 26 specimens of wrapped pipe were buried in earth and connected to the positive side of a 15-volt direct-current circuit, so that the pipe had a potential of about 4.5 volts about the surrounding earth. The ground was quite wet during the spring and fairly moist during the rest of the year. Twenty-four of these specimens were furnished by commercial firms; 12 consisted of 5-ft. lengths of 4-in. wrought-iron pipe wrapped with two alternate layers of pitch and burlap. The other 12 were 5-ft. lengths of 1½-in. wrought-iron pipe covered with four alternate layers of tar and paper. The wrapping was not impregnated and apparently consisted of heavy paper wound spirally over the hot coat of tar, the latter containing 3 or 4% lime (Nichols coating). The electrical connections were soldered on the inside of the pipe, the ends closed with wooden plugs, and capped with several thicknesses of tar paper and pitch. Two specimens of wrapped pipe were made up by the Bureau, each having three coats of insulating paint and two layers of muslin painted on. The pitch-and-burlap specimens failed in from seven to 56 days; the tar-and-paper-wrapped specimens failed in 29 days for the most part, although one lasted 75 days and one failed in two. The paint-and-muslin samples broke down after 36 days. The pipes were left in the ground under test from 10 to 18 months. When they were removed and the wrappings stripped off, they were found to be covered with rough spots and were pitted to considerable depths.

The Bureau concludes that paints, dips and wrappings have little value for protecting pipes from electrolysis. The failure of the coatings they explain by the absorption of moisture which was found when any of the coatings were carefully weighed before and after immersion. These studies, the Bureau cautions, throw no light on the value of these coatings for protecting the various mains from natural soil corrosion, as there is considerable practical evidence that they have a certain protection where no electrical effects are involved.

A Century Rainfall Record at New Bedford, Mass *

By X. H. Goodnough†

SYNOPSIS—A continuous rainfall record, kept by father and son for 92 consecutive years, is here rounded out from other records in the same city to a full century. By years, the rainfall ranged from 34.51 to 65.41 in., with an average of 46.45 in. By months, the range was from 0.1 in June, 1912, to 18.72 in. in August, 1826. The record shows no progressive change in annual rainfall, but does indicate that for periods of 4 to 12 years the annual rainfall continues at a high rate or a low rate. Of six periods of low rainfall within the century only two occurred during its last half, and one of these began in 1908. This suggests the possibility that we are now in a period of lower rainfall and stream flow than has occurred since the middle of the nineteenth century, and points to the necessity of allowing for drier years than have recently been taken into account in calculating the yield of watersheds.

Among the most valuable of rainfall observations in New England are those begun at New Bedford by Samuel Rodman in 1814, and continued by him until his death on Aug. 1, 1876, and afterward continued by his son, Thomas R. Rodman, until he died on Dec. 1, 1905, thus giving a continuous record by these two observers for 92 years. By using the observations at other stations in New Bedford, of which there are several, it is now possible to present a continuous record of rainfall observations at practically the same point for one hundred years.

The rain gage used by the Rodmans was located in the western part of a thickly settled portion of the city upon a ridge about half a mile west of the shore of New Bedford harbor and at an elevation of about 90 ft. above mean sea level. The gage was placed near the ground in a large open area where the conditions were favorable for accurate observation. The records are believed to be wholly reliable.

Since 1905 various observations are available, including those made with a gage located on the roof of the city hall, close to the Rodman residence, at an elevation of about 100 ft. above mean sea level, and those made by Charles H. Adams at a point a short distance north of the Rodman residence and also at an elevation of about 100 ft. above the sea. The city hall observations have been continuous for several years, except that they were interrupted by the burning of the city hall in 1906, and no observations were made in the years 1907 to 1909. Observations are also made by L. J. Hathaway, Jr., of the New Bedford Engineering Department, at a point about six miles north of the Rodman place. These observations are made with a standard gage in an excellent location near the ground at an elevation about 110 ft. above the sea.

The monthly, annual and average precipitation for the years 1814 to 1913 is given in Table I. The table has been made up by using the Rodman records from 1814 to 1905, the observations of Charles H. Adams for 1906 and 1907, and the observations of L. J. Hathaway, Jr.,

TABLE I. A CENTURY RAINFALL RECORD AT NEW BEDFORD, MASS.

1814–1875, Samuel Rodman 1906–1907, Charles H. Adams
1876–1905, Thomas R. Rodman 1908–1913, L. J. Hathaway, Jr.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1814	1.42	8.30	2.16	5.46	4.23	2.27	0.98	6.44	3.06	1.73	5.37	1.65	43.08
1815	4.55	3.33	5.08	4.66	4.11	2.23	1.96	4.36	2.51	1.47	3.45	3.15	40.78
1816	2.13	6.83	2.47	5.50	6.15	2.35	1.01	1.46	6.05	3.96	5.56	0.70	44.13
1817	3.96	5.26	1.77	2.60	1.19	7.00	0.88	3.81	4.09	1.19	6.64	5.54	43.33
1818	3.31	0.91	3.31	3.94	6.79	3.51	3.33	1.66	5.52	2.84	3.35	2.31	40.77
1819	1.25	2.54	7.30	3.31	2.06	3.33	1.57	6.00	4.81	3.84	1.92	1.74	39.66
1820	1.46	5.02	4.44	1.23	5.41	0.46	3.71	4.38	2.01	6.23	3.75	3.23	41.32
1821	2.38	5.96	3.54	6.09	5.43	3.78	2.41	2.23	4.11	4.90	2.94	2.90	45.64
1822	3.29	3.70	3.31	4.76	0.58	2.58	5.14	3.51	6.05	2.97	3.62	2.27	41.78
1823	4.94	5.00	8.43	1.83	7.67	3.20	4.63	3.90	2.08	5.06	3.51	0.74	59.89
1824	3.04	5.32	3.61	5.74	2.69	3.14	2.44	6.21	4.61	2.55	3.54	3.39	47.34
1825	2.80	2.21	6.06	1.42	3.11	3.71	2.06	3.58	1.63	2.78	1.91	7.93	38.09
1826	2.19	3.95	4.08	2.92	0.73	2.11	2.44	18.72	1.44	7.47	4.50	4.32	54.77
1827	3.14	3.99	4.88	3.46	6.94	4.42	4.36	7.63	5.65	6.63	8.42	3.33	62.90
1828	3.02	3.25	4.31	3.48	3.91	4.04	3.04	1.15	3.63	3.62	5.16	0.45	39.04
1829	9.06	5.76	7.03	4.79	8.59	2.92	3.40	7.53	3.49	3.53	7.18	2.13	65.41
1830	4.20	3.07	4.77	2.85	6.63	3.71	12.00	6.32	5.20	3.54	6.18	6.89	64.66
1831	7.47	3.53	5.24	7.38	4.45	3.56	7.26	3.32	5.86	6.04	3.68	3.43	61.18
1832	3.98	5.36	3.02	3.41	6.55	0.41	1.69	9.30	3.00	2.04	4.43	6.52	49.31
1833	3.91	2.37	1.92	2.31	4.14	4.25	1.38	2.57	1.89	5.70	5.51	6.68	42.62
1834	2.76	1.61	1.95	2.94	4.74	7.30	3.42	1.81	5.63	5.25	4.33	3.48	45.12
1835	3.35	1.80	6.52	6.84	2.65	2.52	1.56	10.16	0.90	2.99	2.97	4.95	47.21
1836	9.53	4.62	3.78	2.78	1.76	4.93	1.90	1.12	1.28	2.58	4.53	4.03	42.83
1837	3.69	3.75	4.47	3.33	6.47	4.41	2.15	4.37	0.54	1.34	1.50	3.05	39.07
1838	3.00	2.41	2.90	2.15	3.02	2.84	1.53	2.99	6.71	5.38	4.36	0.97	38.38
1839	0.77	2.71	2.44	4.83	4.96	2.51	2.76	5.89	3.38	5.86	2.01	6.86	44.39
1840	3.25	2.68	3.99	4.56	5.82	3.69	2.14	2.88	3.07	6.93	7.52	5.06	49.59
1841	5.57	1.75	4.06	9.27	1.66	1.44	3.05	5.05	2.90	4.70	5.30	5.85	50.60
1842	2.47	4.34	2.89	3.77	3.17	7.40	1.34	1.97	2.00	0.86	3.06	5.79	39.06
1843	3.94	4.18	4.02	6.19	1.39	1.45	3.31	7.13	1.77	6.86	5.09	5.34	50.67
1844	4.19	2.18	6.65	1.79	2.60	0.90	3.08	2.49	4.15	4.56	4.01	4.13	40.73
1845	4.16	3.00	3.04	1.87	3.79	2.34	3.09	3.37	4.49	4.29	9.72	4.90	48.06
1846	3.09	2.57	1.74	1.20	6.40	0.99	2.61	3.07	2.48	1.69	3.80	4.88	34.51
1847	7.33	4.57	3.25	1.66	2.64	6.46	2.41	7.15	7.20	0.62	1.52	5.10	45.91
1848	3.75	4.22	2.89	1.46	3.98	2.09	4.04	1.16	1.69	5.43	3.30	5.73	40.74
1849	0.88	2.07	5.70	2.23	2.43	1.59	1.22	4.84	1.24	5.71	5.15	3.32	36.42
1850	5.87	2.22	6.05	9.25	4.49	1.23	2.26	6.29	12.06	2.62	2.82	7.51	62.67
1851	2.24	6.20	3.27	4.84	4.78	1.18	9.22	3.49	3.75	5.37	4.76	2.51	51.61
1852	3.91	3.57	5.80	7.36	3.50	1.71	2.55	5.49	2.01	2.03	3.66	4.35	46.14
1853	1.69	4.67	1.28	3.92	4.36	0.92	3.95	2.95	3.84	3.52	3.92	4.45	39.47
1854	1.99	5.67	2.15	6.83	3.56	3.09	7.44	0.24	8.37	1.48	9.66	3.40	53.82
1855	4.73	2.62	1.95	4.24	3.64	1.84	4.79	1.42	0.62	4.66	4.82	5.68	41.00
1856	5.18	1.27	1.64	3.20	3.06	2.18	3.32	2.81	4.56	1.89	3.26	3.68	37.09
1857	6.20	1.94	2.52	5.90	3.09	2.30	4.62	3.94	2.32	2.64	1.84	5.49	43.30
1858	2.48	1.28	2.28	4.39	2.02	5.16	6.75	5.05	3.02	3.20	3.84	4.58	44.03
1859	8.53	4.40	6.04	3.44	5.14	6.16	0.96	4.08	3.64	2.07	2.10	4.34	51.44
1860	1.37	3.50	3.82	2.86	2.30	3.26	2.96	5.00	5.24	1.93	3.44	4.65	39.73
1861	4.19	3.25	4.06	5.44	4.43	3.12	1.70	5.00	3.50	4.30	4.58	2.90	46.46
1862	3.27	3.88	2.80	1.66	2.86	8.05	3.08	1.20	3.98	5.62	4.47	2.46	43.31
1863	2.75	4.16	4.26	4.34	3.52	2.49	4.26	2.51	2.50	1.90	7.03	5.37	45.09
1864	4.35	1.51	5.52	3.10	2.93	1.08	1.50	7.68	2.28	2.35	4.18	4.48	40.96
1865	5.51	3.92	4.90	3.24	6.36	1.66	5.15	1.21	0.26	4.93	4.47	4.40	46.01
1866	2.30	4.54	3.70	2.06	4.15	4.18	1.86	3.60	5.32	2.64	2.65	3.31	40.31
1867	2.84	5.08	5.58	3.19	3.95	2.36	6.03	5.70	2.44	3.96	1.99	4.10	47.11
1868	6.17	2.43	4.64	5.96	9.42	6.51	3.78	4.50	5.91	1.68	2.98	2.34	56.32
1869	3.97	5.34	6.22	1.42	5.92	4.45	1.62	2.76	2.62	6.75	2.30	6.56	49.93
1870	6.20	4.55	3.46	6.20	3.50	3.62	3.05	1.69	1.38	6.64	3.38	3.70	47.17
1871	3.26	3.28	4.86	3.93	2.68	5.39	1.93	6.35	3.34	6.38	6.98	2.34	49.61
1872	2.64	3.42	5.33	2.27	5.51	2.68	5.40	4.04	4.58	5.79	3.58	4.42	47.66
1873	7.34	4.93	2.89	3.98	4.95	1.44	1.32	4.16	3.17	5.34	6.32	6.06	51.70
1874	4.27	4.27	1.69	8.57	5.11	3.70	3.84	7.66	2.94	0.55	3.49	3.34	49.33
1875	3.78	3.67	8.86	4.04	4.20	4.98	4.00	4.60	2.38	3.02	4.85	0.94	48.32
1876	1.02	4.85	5.54	3.85	1.68	0.73	3.86	1.23	4.40	1.62	8.43	5.03	43.19
1877	3.06	1.79	9.42	3.13	2.93	2.36	4.93	3.39	0.83	7.66	6.80	0.95	47.04
1878	5.97	4.05	4.77	4.94	2.91	2.97	2.36	5.38	1.04	5.93	5.74	4.49	50.55
1879	3.43	3.00	8.58	5.13	1.83	2.78	3.89	4.37	3.18	1.19	3.55	4.72	42.31
1880	2.06	2.97	4.85	3.49	1.37	1.96	6.59	5.62	1.69	3.11	2.44	3.92	40.08
1881	4.14	5.83	4.74	1.79	2.39	5.15	0.79	3.29	1.38	5.78	2.04		39.10
1882	4.14	6.83	2.48	4.06	4.74	1.70	1.52	0.89	6.36	4.00	1.91	3.45	41.38
1883	4.73	4.67	2.08	2.93	3.60	1.46	6.92	0.55	2.74	6.36	3.88	3.89	43.51
1884	4.85	5.72	5.29	5.17	3.33	5.38	4.80	8.40	0.98	1.63	3.55	5.30	54.99
1885	5.20	2.76	1.49	2.66	3.15	4.06	1.17	4.23	1.85	4.04	3.16	3.04	36.81
1886	6.77	7.05	5.09	2.19	4.39	1.99	2.69	2.70	2.15	4.33	3.76	6.78	49.85
1887	6.03	6.25	5.83	5.45	2.84	3.15	3.61	0.68	1.71	3.95	2.60	4.38	51.77
1888	4.39	2.63	5.65	2.43	5.57	1.45	5.17	4.89	9.52	2.66	7.39	3.33	55.07
1889	5.79	2.92	3.97	2.31	5.14	3.93	3.44	5.73	3.87	4.11	6.07	3.67	54.71
1890	2.66	2.36	9.77	4.09	6.73	5.90	1.91	3.92	7.55	10.09	1.32	5.49	61.69
1891	8.36	7.00	5.81	2.78	2.44	1.55	1.97	2.09	3.31	6.97	3.17	3.38	47.83
1892	4.48	2.34	5.78	2.31	5.46	2.23	1.72	4.58	3.65	1.86	6.78	1.64	42.83
1893	2.70	6.90	6.18	5.13	4.49	3.00	2.40	4.26	3.38	2.45	2.63	6.75	50.37
1894	4.85	5.18	1.94	4.99	4.46	0.90	0.74	2.18	2.83	7.64	4.55	5.73	45.89
1895	4.04	1.17	4.72	4.32	3.39	8.01	4.91	3.02	1.50	4.39	4.53	2.84	41.83
1896	5.79	2.92	3.97	2.31	5.14	3.93	3.44	5.73	3.87	4.11	6.07	3.67	51.71
1897	3.57	2.53	2.79	4.30	6.07	2.48	3.85	8.57	0.88	1.43	9.74	4.36	50.56
1898	5.78	5.38	3.50	5.39	6.82	0.94	6.04	7.68	1.28	9.83	7.98	2.18	62.80
1899	5.30	5.31	7.35	2.08	1.21	3.72	3.97	2.29	5.00	3.51	1.11	1.99	42.84
1900	5.24	4.62	3.73	2.66	5.31	1.12	2.57	1.63	4.19	6.58	4.65	5.69	44.99
1901	2.66	1.26	7.85	7.08	8.57	1.79	3.22	2.24	3.31	2.13	1.69	10.05	51.84
1902	2.38	5.78	6.91	3.72	1.36	2.48	3.21	2.09	3.92	6.19	1.55	5.53	45.42
1903	4.77	4.52	8.02	5.77	0.81	4.13	2.22	4.47	1.71	4.15	3.57	3.35	47.49
1904	4.99	4.65	2.38	6.84	3.55	5.46	2.22	6.15	2.92	1.36	2.39	5.37	50.08
1905	3.73	2.10	2.88	1.61	1.65	6.77	2.29	4.63	6.36	1.96	3.02	4.30	41.30
1906	3.66	4.21	5.73	2.81	3.51	3.32	4.73	2.26	5.14	3.11	3.16	1.76	43.08
1907	3.35	1.95	3.36	3.25	6.33	2.66	1.09	1.07	7.30	2.52	5.80	6.83	45.51
1908	4.16	4.66	3.60	1.75	4.02	1.69	2.02	5.29	1.27	7.54	1.45	4.43	41.88
1909	4.39	6.44	3.52	6.09	3.50	1.83	0.67	2.27	3.99	1.99	4.73	3.21	42.63
1910	5.65	5.59	1.59	1.86	3.25	4.26	2.49	2.64	1.38	2.03	4.13	3.17	38.03
1911	3.71	2.73	3.32	4.09	0.97	1.92	5.33	4.03	3.46	2.33	7.32	4.12	43.18
1912	4.97	3.69	9.40	3.45	4.67	0.10	1.03	5.49	9.30	1.19	3.89	6.65	49.76
1913	4.82	4.09	3.61	4.59	1.64	0.85	1.97	4.96	2.35	10.09	2.83	4.68	45.87

*Portions of this article, especially Table III and the diagram (Fig. 2) showing progressive rainfall, were presented to the New England Water-Works Association on Dec. 10, 1913, in the course of a lengthy paper on New England rainfall records.

†Chief Engineer, Massachusetts State Department of Health, Boston, Mass.

TABLE II. EXTREMES OF RAINFALL AT NEW BEDFORD, MASS., 1814–1913
SHOWING PRECIPITATION IN EACH MONTH ARRANGED IN ORDER FROM MINIMUM TO MAXIMUM

January		February		March		April		May		June		July		August		September		October		November		December		Total	
Year	Amt.	Year	Amt.	Year	Amt.	Year	Amt.	Year	Amt.	Year	Amt.	Year	Amt.	Year	Amt.	Year	Amt.	Year	Amt.	Year	Amt.	Year	Amt.	Year	Amt.
1839	0.77	1819	0.91	1853	1.28	1846	1.20	1822	0.58	1912	0.10	1909	0.67	1854	0.24	1865	0.26	1874	0.55	1899	1.11	1838	0.45	1846	34.51
1849	0.88	1895	1.17	1885	1.49	1820	1.23	1826	0.73	1832	0.41	1894	0.74	1881	0.79	1837	0.54	1847	0.62	1990	1.32	1816	0.70	1849	36.42
1876	1.02	1901	1.26	1874	1.59	1896	1.24	1903	0.81	1820	0.46	1817	0.88	1883	0.85	1855	0.62	1842	0.86	1908	1.45	1875	0.94	1885	36.81
1819	1.25	1856	1.27	1910	1.59	1825	1.42	1911	0.97	1876	0.73	1859	0.96	1882	0.89	1877	0.83	1817	1.19	1837	1.50	1877	0.95	1856	37.09
1860	1.37	1858	1.38	1856	1.64	1869	1.42	1817	1.19	1913	0.85	1814	0.99	1907	1.07	1997	0.88	1879	1.19	1847	1.52	1838	0.97	1910	38.02
1831	7.47	1816	6.82	1903	8.08	1852	7.36	1827	6.94	1905	6.77	1883	6.92	1832	8.30	1890	7.55	1894	7.84	1827	8.42	1830	6.89	1898	62.60
1891	8.66	1893	6.90	1912	8.40	1974	8.57	1833	7.67	1817	7.00	1831	7.26	1884	8.49	1854	8.37	1877	7.66	1876	8.42	1950	7.51	1850	62.67
1859	8.53	1891	7.00	1823	8.43	1904	8.84	1901	8.57	1834	7.30	1854	7.44	1897	8.57	1996	8.87	1898	9.83	1854	9.66	1825	7.93	1827	62.90
1829	9.06	1896	7.05	1977	9.42	1850	9.25	1829	8.59	1842	7.40	1851	9.32	1835	10.16	1888	9.52	1890	10.09	1845	9.72	1833	9.74	1830	64.66
1836	9.53	1814	8.30	1990	9.77	1841	9.27	1868	9.42	1862	9.05	1830	12.00	1826	18.72	1850	12.06	1913	10.09	1897	9.74	1901	10.05	1829	65.41
Total	400.36		367.98		433.85		394.74		396.48		307.32		323.26		417.27		360.81		393.51		424.49		415.14		4645.35
	4.01		3.68		4.34		3.95		3.96		3.07		3.23		4.17		3.51		3.94		4.24		4.15		46.45

from 1908 to 1913. If observations at other stations had been used for the period since 1905, the difference in the results given in the table would not be important.

For convenience in the study of these records, Table II is presented, showing the extremes of precipitation in each month and year, arranged in order from the minimum to the maximum amount.

The average annual rainfall at New Bedford, as shown by these records, during this period of 100 years, was 46.45 in. The driest year was 1846, with a rainfall of 34.51 in., and the wettest, 1829, with a rainfall of 65.41 in. The driest month was June, 1912, with a precipitation of 0.10 in. The wettest month was August, 1826, with a total precipitation of 18.72 in. It is interesting to note that it was also in the month of August, 1826, that the Willey family was overwhelmed by an avalanche in the Crawford Notch [White Mountains, in New Hampshire], attributed to the excessive rainfall.

The diagram, Fig. 1, shows the variation year by year in the annual rainfall and also the years when the precipitation was less than or greater than the average.

One of the chief values of continuous observation of rainfall covering a very long period at the same place is the evidence that such a record may give as to a progressive change in the amount of annual precipitation. No indication of such a change is shown by these records. A study of the diagram and tables indicates that periods of several years of continuous high or low or average rainfall succeed each other and that these periods have generally averaged, in this instance, eight or ten years in length (see Table III).

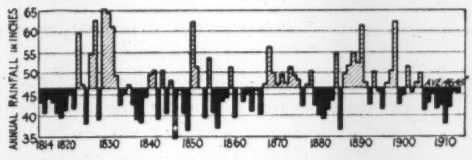


FIG. 1.

(Annual rainfall at New Bedford, Mass., for the 100 years 1814 to 1913 and the excess or deficiency for each year as compared with the average for the century.)

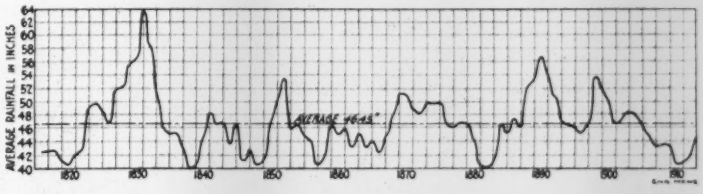


FIG. 2

(Three-year progressive average rainfalls at New Bedford, Mass., 1814 to 1913, plotted on third years.)

The variations in the annual rainfall are, however, shown perhaps more satisfactorily by the diagram, Fig. 2, which shows the three-year progressive averages of the rainfall in this 100-year period. This diagram shows that there have been six periods of very low rainfall at New Bedford since 1814, or an average of one in about 17 years. There was about an equal number of periods of average or high rainfall, the maximum rainfall occurring in the years about 1830, when the precipitation was much greater than at any subsequent time, the nearest approach to it being the period of a few years about 1890.

This diagram is interesting as showing that of the six periods of very low rainfall at New Bedford only two have occurred in the last fifty years, namely, the period from 1880 to 1883, and the period from 1908 to 1911.

So far as these observations show, there is no indication of variations covering periods longer than about 17 years, but studies of other observations in New England indicate quite clearly that the rainfall for at least 35 years preceding the year 1850, and possibly for a much longer period, was, except for the years about 1830, very much less than the average; while the rainfall from 1850 to about 1903, except for a few years about 1883, was nearly always greater than the average. Since 1903 the rainfall in most parts of New England has averaged much less than the normal amount.

The New Bedford records agree in general with those of other long-continued observations in New England, except that they show as a rule somewhat less rainfall in some of the years between 1849 and 1879, especially in years between 1850 and 1860, than are shown by records of rainfall in this period at stations farther west and north.

The average monthly rainfall at New Bedford during the entire period of 100 years is shown graphically by Fig. 3, a glance at which will show that the month of least rainfall is June, when the quantity has been but little in

TABLE III—TABLE SHOWING GROUPS OF DRY, WET AND AVERAGE YEARS AT NEW BEDFORD

Period	Number of years	Average rainfall per year
1814-1822	9	42.28
1823-1832	10	54.26
1833-1839	7	42.79
1840-1843	4	47.48
1844-1849	6	41.06
1850-1854	5	50.74
1855-1866	12	43.23
1867-1878	12	48.91
1879-1885	7	42.59
1886-1890	5	54.22
1891-1895	5	45.69
1896-1904	9	49.34
1905-1912	8	42.54

excess of 3 in., followed by July, with a rainfall of about 3.5 in. The maximum rainfall has occurred in March, closely followed by November, but there is also a high rainfall in the month of August, the quantity being much greater than in the other summer months.

A study of the seasonal distribution of the rainfall is

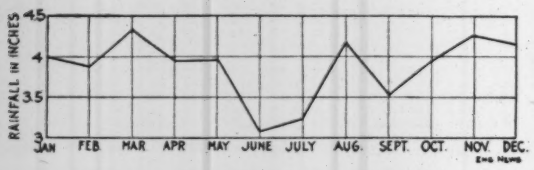


FIG. 3. MONTHLY RAINFALL AVERAGES AT NEW BEDFORD, MASS., 1814 TO 1913

interesting. The average rainfall for the months of December, January and February, taking in each case consecutive months, shows no material variation in the amount of the winter precipitation throughout this long period. The minimum winter rainfall ever recorded occurred apparently in the year of 1838-1839, when the average precipitation per month was 1.48 in. Next in order comes the winter of 1818-1819, with an average precipitation of 2.03 in. per month, and then 1901 with a monthly precipitation of 2.20 in. Next in order come 1876, 1907, 1872, 1890 and 1820, in all of which the precipitation averaged less than 2.75 in. per month. The maximum winter rainfall occurred in 1891, when the average precipitation was 6.95 in. per month. Next in order comes the year 1836 with 6.37 in. per month, then 1887 with 6.35 in., 1824 with 6.30 in., and 1902 with 6.07 in., these being all of the winters in which the rainfall exceeded 6 in. per month.

A study of the rainfall in the spring months, March, April and May, shows that the maximum amount occurred in 1901, when the average monthly precipitation was 7.83 in. Then follow 1890 with 6.90 in. and 1829 with 6.80 in. The minimum monthly precipitation in this period occurred in 1817, and amounted to 1.85 in. per month. Next in order comes 1905 with a monthly precipitation of 2.05 and then 1910 with 2.23 in. Low spring rainfalls were very much more common in the first 50 years of the observations at New Bedford, that is, from 1814 to 1863, than they have been in the last 50 years. In the first 50 years the period of spring rainfall averaged less than 3 in. per month in 13 of the 50 years, viz., 1817, 1822, 1826, 1833, 1836, 1838, 1845, 1847, 1848, 1856, 1858, 1860, 1862, while in the last 50 years the spring rainfall has fallen below 3 in. only in the years 1881, 1883, 1885, 1905, 1910 and 1911.

The average rainfall in the summer months, June, July and August, was highest in 1826, when it amounted to 7.76 in. per month, due to the great rainfall in the month of August of that year. Next in order comes 1830 with an average monthly precipitation of 7.31, then 1884 with 6.22 in. Except in these years, the average monthly precipitation in summer has exceeded 5 in. only four times. The minimum summer precipitation occurred in 1894, when the average monthly quantity was 1.27 in. Then come in order 1882 with 1.37 in., 1909 with 1.59 in. per month, 1816 with 1.60 in., and 1907 with 1.61 in. There were three other years, viz., 1891, 1900 and 1876, when the average summer precipitation was less than 2 in. A summer precipitation averaging less than 2 in. per month occurred but once in the first 50 years of these observations and has occurred seven times within the last 4[illegible] years.

In the autumn months, September, October and November, the minimum precipitation throughout this period occurred in 1837, when the average quantity was 1.13 in. per month, by far the lowest recorded in the 100 years. Next to 1837, the driest autumn was in 1842, when the quantity amounted to 1.97 in. Besides these years the average monthly rainfall in the autumn has been less than 3 in. in 20 years of the period.

So far as can be judged, these observations seem to indicate on the whole that the rainfall of the spring months has been higher, as a rule, in the last 50 years than in the earlier half of the period covered by these observations, while the frequency of intense summer droughts has been greater in recent years than in the earlier half of the period covered by the observations. These differences are not of great importance, however, and with a different grouping of the months they largely disappear.

The chief result shown by a study of this record of 100 years, which is confirmed by other observations in New England, is that years and periods of years occurred in the early part of the 19th century, in which the precipitation was either lower than in any similar period of recent years or was so distributed as to be likely to produce a much lower flow in the streams than in any similar periods in recent times. They indicate the necessity of making allowance in calculations of yield of watersheds for the occurrence of drier periods than those which have ordinarily hitherto been regarded as the driest which are likely to be experienced. If there is a variation in the rainfall covering long periods of fifty years or more, it is possible that we are entering now a period which will contain years of much lower stream flow than any that have occurred since the middle of the 19th century.

State Supervision of Engineering Work in Pennsylvania

We published in our issue of Oct. 22 (p. 850) the report of a committee of the Association of Philadelphia Members of the American Society of Civil Engineers relative to the proposed law requiring engineers practicing in the State of Pennsylvania to be examined and licensed. At a meeting of the association on Oct. 26, this committee presented a supplementary report in which it was recommended that the state should supervise the carrying out of engineering work to safeguard the interests of the public. This is in effect a continuation of the established policy of the state to supervise the construction of dams and reservoirs, a policy entered upon after the failure of the Austin dam in 1911.

We print the substance of this report as follows:

In its original report the committee recommended the creation of a state engineering department. It desires now to point out that irrespective of the creation of such a department, it is of fundamental importance that the state should recognize its responsibility for safeguarding the interests of the public in connection with engineering work.

INADEQUACY OF EXISTING LAWS GOVERNING ENGINEERING WORKS UNDER PUBLIC AUSPICES.

Outside of cities of the first and second class, viz.: Philadelphia, Pittsburgh and Scranton, the usual conditions governing the employment of engineers is a majority vote of county commissioners or local council. Engineers thus

employed are held to little or no direct responsibility under the law. These conditions hold out no assurance of professional competency and integrity on the part of engineers thus employed, for duties in connection with which incompetency is likely to result not only in the waste of public funds, but in the jeopardy of human life, health and safety. The existence of these conditions is discreditable to the State of Pennsylvania, and it is earnestly recommended that adequate remedial state measures be promptly enacted.

In general it is desirable that the employment, retention or discharge of engineers in public service should be governed by the same principles as under private corporate management. The following suggestions are offered as indicative in a general way of the requirements of the situation, without aiming at completeness or the best means of adapting them to existing conditions:

1. Civil Service Examinations: It is highly desirable that the appointment of engineers and technical men in general, with duties of a nature in which competency may be readily determined by examination, should be subject to state or municipal civil service regulation. In cities of the first and second class, such civil service examinations may properly be conducted under independent management. For other municipalities, counties and boroughs it is desirable that such civil service examinations be conducted by a state department, in order that these examinations may be governed by reasonable and consistent standards, and that a single body may be charged with the enforcement of such standards.

2. Exemptions from Civil Service Examinations: It is desirable that appointments to engineering or technical positions above a certain rank should not be governed by competitive civil service examinations, but that the appointees should be chosen on the basis of their professional record. It is desirable that such appointments should be made either by the state civil service examination department direct, or at the initiative of designated state officers, but with its approval.

3. Other Functions of the State Civil Service Examination Department:

(a) It is desirable that the state civil service examination department should be authorized to investigate charges of incompetency or official dereliction on the part of engineers and other technical men appointed through civil service, except employees of cities of the first and second class, and that it alone should be empowered to disqualify such public servants, and only for adequate cause.

(b) It is further desirable that the state civil service examination department should act in an advisory capacity in connection with the employment of consulting engineers or experts for special temporary engagements, and that no engagements of that character should be legal without its approval.

This plan would tend to prevent the engagement through ignorance, or from interested or political motives, of incompetent or unscrupulous engineers and technical men and would likewise tend to facilitate the approval of plans for public works on the part of the several state departments concerned. It would also serve to minimize abuse under the system by which nominally free engineering services are rendered by commercial concerns, and by which patented schemes and devices of questionable merit, or of unnecessary cost, are prescribed in specifications for public works. Finally, it should serve as an effective check upon the prevailing method by which professional engagements are made a matter of competitive bidding. This system, which cannot be too strongly condemned, places a premium on incompetency and unscrupulousness at the expense of public interests. Experienced, able and reputable engineers refrain from participating in such competitions and would, in fact, have little or no chance of obtaining a commission under its operation.

(c) It should be one of the duties of the state civil service examination department to educate public and official sentiment as to methods of procedure in the employment of competent engineers and other technical men, and as to the danger to public interests through the engagement of incompetent men from mistaken motives of economy or other reasons.

In conclusion the committee recommends the creation of a state department of public works which shall be in charge of the administration of the above proposed (1) civil service examination system and (2) supervisory system of plans and inspection of engineering works, and in which shall be centralized such other matters relating to public engineering activities as may seem proper.

The principles embodied in the above report were approved by the Association of Members of the American Society of Civil Engineers at its meeting on Oct. 26 and by the Engineers' Club of Philadelphia at its meeting on Oct. 27.

A Double Loop on a Mountain Railway

The corkscrew loop shown in the view on this page is the Cimbatti Loop on the narrow-gage railway leading up to the hill station at Darjeeling, in Bengal, at the foothills of the Himalayas. This line begins at a point a short distance north of the Ganges River, which is reached from Calcutta by a standard-gage road, and continues on heavy grade to make the 7000-ft. rise to Darjeeling. At the loop shown, the track makes two complete circles each of a radius a little over 100 ft. Such construction is fairly common in the Luna Parks or other amusement parks of this country, but hardly to be expected on a regular passenger- and freight-carrying line.

THE CIMBATTI LOOP ON THE DARJEELING-CALCUTTA RAILWAY, INDIA

Slate Creek Bridge: Building a Concrete Arch Bridge 56 Mi. from Rail

By Jean H. Knox*

The first reinforced-concrete bridge in the Sierra Nevada Mountains of California was completed in October, 1913, spanning Slate Creek on the boundary line between Plumas and Sierra Counties.

In the spring of last year it was found that the Slate Creek bridge, although constructed only eight years, was in a state of ill repair and unsafe for further traffic. This structure, a 72-ft. combination wood-and-steel truss bridge, supported by concrete and steel cylinders, was the fifth bridge to be constructed at this crossing since the early fifties.

For years the people had accepted as fact the statement that the first cost of a reinforced-concrete bridge in a rough, mountainous country, isolated from a railroad, was prohibitive, as compared with a wooden or a steel structure. The county engineer of Plumas County and the supervisors decided to make a test case by competitive bids on various types of bridges. The lowest bid received for construction of a steel bridge with wood floor and concrete abutments was $3597, and the lowest bid for a reinforced-concrete bridge was $3500. The latter bid was accepted.

A brief description will serve to illustrate the salient features of the accepted bridge. The structure is a three-hinged rib arch. It was designed for a uniform live-load of 150 lb. per sq.ft., or a 20-ton roller. With an assumed ratio of moduli of 15, the allowed stresses were 600 lb. compression and 60 lb. shear on the concrete, and 16,000 lb. tension in the steel.

The principal features of the structure are shown by the drawing, Fig. 3. The abutments (see also view, Fig. 2) are in pairs, solid type, with forepart extending out as a cantilever to meet the haunch of the arch-rib. A diaphragm brace-beam connects each pair of abutments near the springing line of the arch. The ribs, two in number, span 66½ ft. c. to c. of end hinges, with a rise of 8 ft. 4 in. They are 12 ft. apart on centers; eight diaphragm brace-beams connect the ribs.

Columns rising from the arch-ribs support transverse floor beams, which cantilever 3 ft. out beyond either column; they were designed as T-beams. The floor of the bridge was designed as a succession of arched longitudinal T-beams running continuous over supports. Expansion joints are located over the hinges at crown and haunches. The columns and floor of the approach spans are similar to those of the arch span.

Ornamental balustrades extend the length of the bridge on either curb line. A blanket wearing surface ½ in. to 1 in. thick, composed of fine, dry gravel and asphaltum road oil, covers the surface of the roadway.

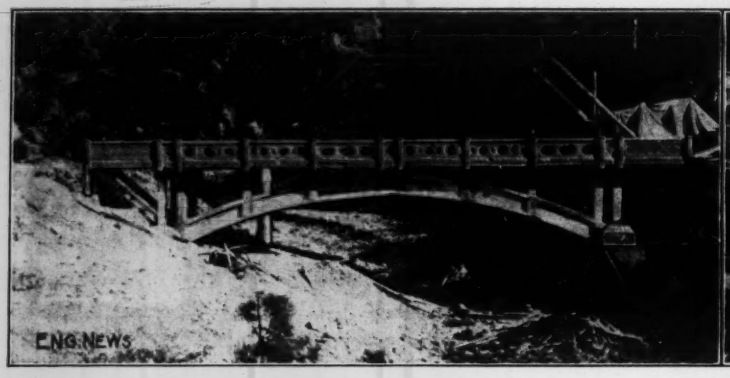


Fig. 1. Old and New Bridges

Fig. 2. East Abutment; Cantilever Type

(Slate Creek arch bridge in the Sierras, 56 miles from rail, cheaper than a steel bridge.)

Standard specifications governed the kind and quality of all materials used in construction.

Conditions at Site Governing Construction

The bridge is located between La Porte in Plumas County, and St. Louis in Sierra County. The site is about 35 mi. south of Quincy, the county seat of Plumas County, and 56 mi. east of Oroville, in Butte County. The grades on the wagon roads were more severe than the foot-hill route from Oroville, so all equipment and materials were shipped by rail to the latter town and freighted by six-horse teams to the bridge site. The teams, hauling about 3½ tons, made the round trip in 6 to 7 days. The cost of hauling amounted to nearly 25% of the total contract price.

Slate Creek, in the vicinity of the bridge, flows through a deep, tortuous, rocky cañon, and the road crossing is located near the outside point of a bend in the creek. In the early days of mining, a tunnel was driven, making a cut-off so that the creek bed could be mined, and the bed of the stream at the bridge site is practically dry.

Bedrock was exposed on one bank at one of the abutments of the bridge, while on the other bank it was necessary to excavate through a gravel bank down about 14 ft. to bedrock. This bed of gravel had resulted from the operations of hydraulic placer gold mining, partially filling the stream bed with gravel débris or tailings. Through more than a score of years this material has been washed

*Chief Engineer, Commonwealth Engineering Company, Plaza Bldg., Oakland, Calif.

...l carried away by scouring, till at this point there was ...t a clean bank of gravel 25 ft. high by 25 ft. wide near ...e end of the bridge site. The convenient location and ...ellent quality of this gravel made the problem of se...ring concrete aggregate a simple one. The gravel varied ...om well graded sand to 2-in. round gravel. The sand mixing platform was then located on this portion of the completed floor. From this location the arch-ribs were poured and all that portion of the superstructure on the north side. The mixing platform was moved ahead on the floor as rapidly as completed, the concrete being shoveled directly into the forms or placed by means of metal

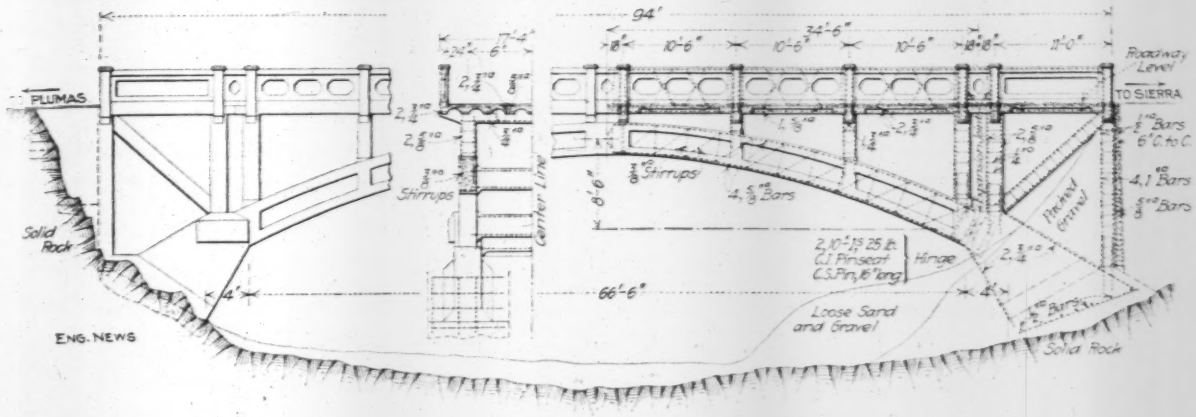


FIG. 3. DESIGN DETAILS OF SLATE CREEK BRIDGE

content was found by screening to be about equal to the coarse aggregate retained on a ¼-in. screen. The sand content was determined from time to time as the work progressed, enough screened coarse aggregate being added to make the proper proportions.

FORMS: CONCRETING

The concrete was mixed by hand. For concreting the abutments the mixing platform was placed on the side of the gravel bank, near the north abutment, and at a

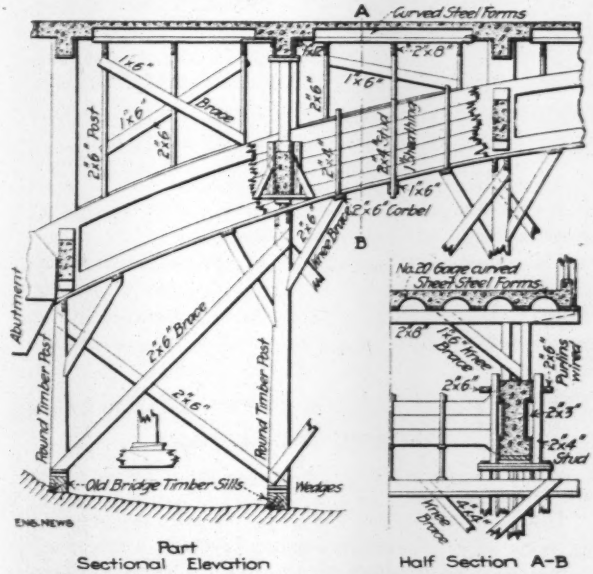


FIG. 4. FALSEWORK AND FORMS FOR SLATE CREEK BRIDGE

height that permitted the placing of most of the concrete for this abutment with chutes. Concrete buggies and wheelbarrows were used for placing concrete in the south abutment. Then the concrete for the short approach span over the north abutment was placed, and the chutes. These chutes were made from the rolled-metal forms which were used for the arched-floor system.

Fig. 4 shows the form construction. Lumber for forms and falsework was hauled from a mill located about 20 mi. distant from the bridge. About 6 M ft. of sawed lumber was used. Round poles cut near the vicinity of the work were used for centering and falsework posts.

The arch-rib forms were supported by vertical posts at points just below the spandrel columns, 10½ ft. apart. The posts were connected at the top by two transverse 2x6-in. ledgers housed into the posts and bolted, and were further braced in two directions with 2x6-in. pieces. The soffit of the arch-ribs was formed with 1½x18-in. lumber bent to the true arch curve and held in position by knee-bracing to the posts.

Side forms for arch-ribs on the north half of bridge were made in sections, jointed at the spandrel columns, and, with the brace-beam forms, were used again for the south half. Forms for the spandrel columns and transverse floor-beams were also used twice.

The small arches in the floor were formed by using curved sheet steel of 20 gage, which was held at the corners of the 2x8-in. piece which formed the stem of the longitudinal T-beams, by 6d. nails. These curved steel forms were removed in from three to four days and were used four times. The forms for each floor panel were supported by three 2x8 joists 18 ft. long, resting on 2x6 posts, which in turn rested on the arch-ribs.

The railing panels, 10 ft. long, 2½ ft. high and 2½ in. thick, were cast two at a time on a level platform at one end of the bridge. After curing sufficiently, they were placed in position in the bridge curbs, framing into the forms for top rail and posts, which were then poured in place. Forms for one-fourth of total railing were framed, then used four times.

For the roadway wearing surface, the hot asphaltum oil was first applied directly on the concrete slab, using ½ gal. per sq.yd.; then the gravel was spread over the area and rolled to a smooth, compact surface. The roller was made by casting concrete in a form about 2 ft. wide and

2½ ft. in diameter, cored through the center for wood axle and crossed shafts.

Labor, Materials and Costs

Excepting the time used for removal of falsework and the old combination bridge adjacent to the site, the work was completed in 65 working days.

The working force consisted of one foreman, and 4 to 10 men, the majority of whom were common laborers who lived in the vicinity of the work. The men were willing workers but unskilled in concrete construction. The minimum wage was $3 for an 8-hr. day.

Materials in the bridge amounted to 60 cu.yd. of 1:3:5 concrete in the substructure, and 93 cu.yd. of 1:2:4 concrete in the superstructure, and 14,000 lb. of reinforcing steel. The structural and cast-metal hinges had a total weight of about 1800 lb.

The contract price for the bridge was $3500, and $170.80 was allowed for extra earthwork and razing the old combination bridge. The total cost of the bridge per square foot of floor area was $2.44.

Including superintendence, the following unit labor costs were deduced:

Bending and placing reinforcing steel.....	$0.012	per lb.
Mixing and placing concrete	2.14	per cu.yd.
Centering and falsework, including striking and removal	20.70	per M ft.
Forms and cost of stripping	39.30	per M ft.
or	4.00	per cu.yd.
Railing, in place	1.00	per lin.ft.

The Slate Creek bridge was constructed and paid for jointly by the Counties of Plumas and Sierra, but the work was contracted for and directed by Plumas County. B. F. Barbee is surveyor for Plumas County and was directly in charge of the work for the county. The Commonwealth Engineering Co., Inc., of Oakland, were the designing and supervising engineers. Haviland, Dozier & Tibbetts, of San Francisco, were the contractors. E. R. Kauffman was resident engineer. D. M. McPhetres, who furnished the cost data and history for this article, was in charge of the work for the contractors.

Three-Stage Air Compressor for 2500-Lb. Pressure

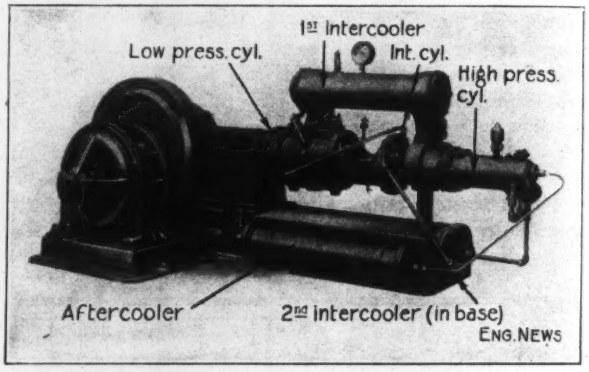
Air compressors with a terminal pressure of 2500 lb. per sq.in. have been built recently for the U. S. Navy Department, for use in the testing of torpedoes. They are of the horizontal type, with an electric motor geared to the compressor crankshaft. The lubrication is on the splash system, the crank dipping into an oil pocket. The tandem cylinders are 7, 4⅜ and 1¾ in. in diameter and have a 10-in. stroke. The delivery capacity is 20 cu.ft. per hr. at 2500 lb. pressure, with a speed of 175 r.p.m., and about 36 hp. at the crankshaft.

The low-pressure cylinder is double-acting, is water-jacketed on the barrel and ends, and has vertical poppet valves. The intermediate- and high-pressure cylinders are single-acting (with plungers instead of pistons); their barrels have water jackets, but the heads are too small to make jacketing desirable. The intermediate cylinder has poppet valves, located at one side. The high-pressure cylinder has special poppet inlet and discharge valves made of heat-treated nickel-steel. Each valve works in a taper plug, ground to fit a tapered opening at the rear end of the cylinder. The springs are within the plugs.

The air from the low-pressure cylinder passes to intercooler of the ordinary type, with copper tubes, wh the air from the intermediate cylinder passes an intercooler consisting of a coil of seamless copp pipe placed in the bedplate. From the high-press cylinder the air passes to an aftercooler consisting of coil of heavy seamless copper pipe placed in a steel ta at the side of the bedplate. This is to provide again drop in pressure in the storage reservoir due to a fa in temperature.

Salt water is to be used for cooling, and all the iro and steel parts of cylinder jackets, intercoolers and after cooler with which this water will come in contact hav been galvanized. To avoid galvanizing the base, however the second intercooler is placed in a galvanized tank i the base. All pipes and connections are of brass, and th drain cocks are of bronze.

Six of these compressors have been built, for six navy yards. Three of these have alternating-current motors of slip-ring type wound for 220-volt three-phase 60-cycle current, and running at 855 r.p.m. The others have 220-volt compound-wound direct-current motors with commutating poles, and running at 900 r.p.m. The compressor has a combined flywheel and gear wheel, having



Three-Stage Air Compressor Supplying Air at 2500-Lb. Pressure for Testing Torpedoes, U. S. Navy
(Sullivan Machinery Co., Chicago, builders.)

an internal gear bolted inside the rim. This engages with a cloth pinion on the motor shaft.

The compressors were built by the Sullivan Machinery Co., of Chicago. They were subjected to an eight-hour official test under pressure as high as 3200 lb., with satisfactory results.

San Francisco's New Municipal Street Railways

By A. J. Cleary*

Development—San Francisco officially declared itself in favor of municipal ownership in 1900, when its electorate adopted a new City Charter. The first proposed bond issue of $2,000,000 for a municipal railroad was defeated by a narrow margin at an election held in June, 1909; at a second election in December of the same year, two municipal-railway bond issues were carried by a three-to-one majority. One provided $1,900,000 to build an electric line on Geary St. from Market

*Assistant City Engineer, San Francisco.

the ocean; the second applied $120,000 to the construction of a line down Market St. from Geary to the ferries. Construction of the Geary St. railway started in the summer of 1911 and was completed in June, 1913. The cost was $103,564 per mile, and the financial returns on the money expended have been very satisfactory. Thus encouraged and realizing that the success of the Panama-

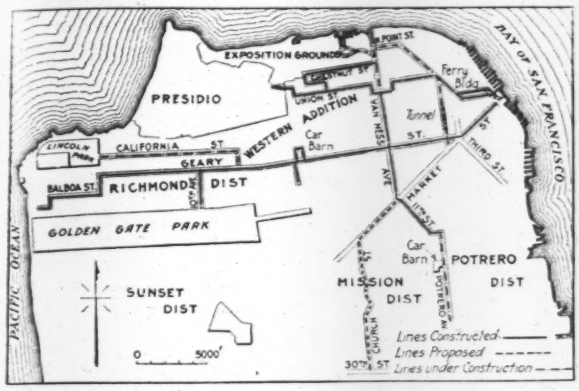


FIG. 1. MAP OF SAN FRANCISCO MUNICIPAL RAILWAYS

Pacific Exposition depends largely on the adequacy of street-railway facilities, in August, 1913, the citizens approved a second bond issue of $3,500,000 for new lines. The entire municipal system is shown in Fig. 1. Excellent progress has been made in construction and it is expected that all of the lines will be in operation before the end of 1914.

TRACK CONSTRUCTION—The standard track construction consisted of 9-in., 106-lb. girder rails in 60- and 62-ft. lengths, laid on tie-plates over 6x8-in. by 8-ft. redwood cross-ties, at 2-ft. centers, with 7/8-in. round tie-rods spaced 10 ft. in straight track and 5 ft. in curves. Rails in curves are supported by braced tie-plates. Joints have 36-in., 12-bolt plates of standard section. There is 8 in. of broken-rock ballast under the ties in standard track and 15 in. for special work. Copper bonds (900,000 circ. mil) are brazed directly to the rails.

The curves have been designed to give passing cars a clearance of not less than 12 in. All track special work is of solid manganese steel and consists, so far as possible, of interchangeable switches, mates, frogs and cross-pieces, which, in various combinations, will compose any layout of branch-offs, cross-overs and right-angle crossings or combinations thereof, in standard 9-in. track. In the design of these standard pieces, an endeavor was made to reduce the number to a minimum, as their interchangeability will facilitate maintenance. The total number of pieces of different design is 35. The section of all joints in track special work is such as to permit the use of the standard joint plates without modification.

CONSTRUCTION WORK—In order to hasten construction, several labor-saving devices were introduced. A 3-in. sharpened circular steel flange attached to the wheel of a steam roller, was used in cutting the asphalt surface of the street pavement. The top and the concrete base beneath were then broken by a 2-ton drop-hammer pile-driver, mounted on skids to permit swinging from side to side of the trench and moving forward as the pavement was broken up. The broken concrete base was next removed from the trench and fed to a movable crusher, which reduced it to ballast size. The roadbed was then excavated to subgrade, by means of a half-yard steam shovel, and 6 in. of crushed concrete was spread and flushed with sand. After this the surface was compacted with a 10-ton steam roller.

Ties were laid, rails were placed on tie-plates, joints were bolted temporarily and the rails spiked to gage. The maximum permissible variation of gage from standard (4 ft. 8½ in.) is 1/16 in. All rail bending to horizontal and vertical curves was done by the contractor—part in the field by a hydraulic bender operated by a hand pump, and part by power machines at the rolling mills or railroad shops. Such drilling and reaming as was necessary was done with a portable electric track drill. After spiking, the lining and surfacing gang adjusted the track to perfect line, gage and grade. Finally the spaces between ties were filled with ballast, the concrete base for header blocks and pavement was poured and the pavement replaced.

CARS—For the Municipal lines, 125 new cars have been purchased. They are of the "California semi-steel" type, 47 ft. 1 in. long over bumpers, 9 ft. 2½ in. wide and 11 ft. 8 in. high from the top of the rail to the top of the trolley board. All structural parts, up to window sills, are of steel and so formed as to give extreme rigidity with minimum weight. The construction above the window-sill line is of the finest grades of California wood. For instance, the roof has no inner lining as the roof boards were of white cedar, which was purchased in San Francisco by the car builders and shipped east to the factory. This wood was selected for grain and color and has been varnished, presenting a very pleasing appearance and reducing the weight of roof structure without sacrificing strength.

Each car has four 60-hp., 600-volt interpole motors with multiple-unit switch control. The cars can be rapidly accelerated to full speed and can surmount heavy grades

FIG. 2. SPECIAL TRACKWORK OF SAN FRANCISCO MUNICIPAL RAILWAYS, AT VAN NESS AVE. AND GEARY ST.

at normal speed. Special additional features in air-brake equipment have been provided as emergency devices. A valve under the body will set the brakes if air-brake pipes or appurtenances are disabled; at each end of the car, within reach of the conductor, is an additional emergency valve.

Construction of the Municipal Railroads and their equipment is under the direction of M. M. O'Shaughnessy,

City Engineer. T. W. Ransome is Consulting Engineer. L. E. Hunt is Chief Assistant Engineer and N. A. Eckart, Engineer in Charge of Construction; P. J. Ost is Electrical Engineer.

A Large Coaling Station at Toledo; L. S. & M. S. Ry.

A large coaling station for locomotives forms a part of the shop and terminal improvements recently completed by the Lake Shore & Michigan Southern Ry. at Air Line Junction, about four miles west of Toledo, Ohio. It is of the bridge type, spanning seven tracks, and has an overhead storage bunker of 1000 tons capacity, with a weighing hopper over each track. Provision is made also for delivering sand to the engines. Water cranes are located along the engine tracks which pass under the coaling station. About 80 locomotives take coal daily at this point, with an average supply of 8 tons per engine.

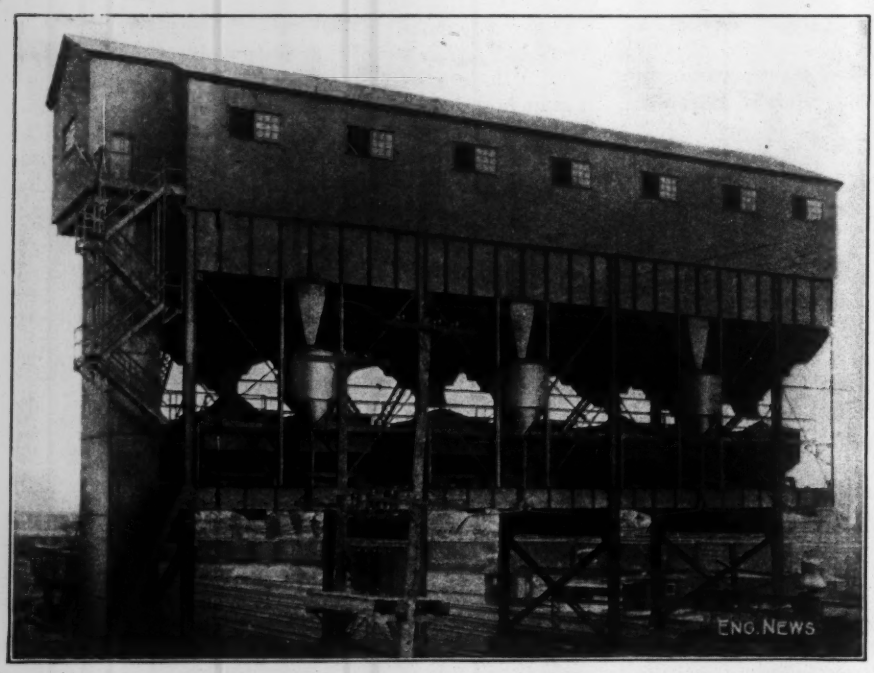


FIG. 1. A LARGE COALING STATION ON THE LAKE SHORE & MICHIGAN SOUTHERN RY. AT AIR LINE JUNCTION, OHIO

(The station serves seven tracks and has a bunker capacity of 1000 tons.)

The construction is shown in Fig. 2, and Fig. 1 is a view of the completed coaling station. The steel bunker structure is about 120 ft. long, supported on four sets of columns 31 ft. 6 in. c. to c. At one end is the tower of the elevating conveyor, carrying the coal from track hoppers to the bins, and this end is fitted with diagonal braces to resist any tendency to longitudinal movement. At the further end the structure extends as a cantilever about 12 ft. beyond the columns, so as to serve the seventh track. The side sheathing and the roofing are of corrugated ingot iron. The erection was done with a stiff-leg derrick, having a 113-ft. boom, the derrick occupying one position during the entire work.

At the elevator end, there are two coaling tracks, each with two track hoppers of reinforced-concrete construction to receive the coal from dump cars. Beneath each pair of hoppers is a cracker for breaking large lumps and sizing the coal. A feeder of the reciprocating plate type carries the coal from the discharge opening of the hopper to the cracker. If the sizing is not necessary, the coal can be delivered directly to either of the two elevating conveyors, being fed to the buckets by a revolving loader having four buckets and driven from the conveyor chain.

The two conveyors have chains of steel-bar links 17½ in. long with 6-in. rollers riding on a channel track. The buckets are 30 in. wide, spaced 35 in. apart, and each holds about 250 lb. of coal. The conveyor runs vertically in the inclosed end tower and then extends horizontally over the storage bunker, the buckets being dumped by means of tilting devices, which can be set at any desired point in the horizontal line of travel. These dumpers have cams which engage with cams on the buckets. The driving mechanism is mounted above the bins, and each conveyor is driven at a speed of about 40 ft. per min. by a 25-hp. motor.

Over the track and beneath the discharge gate of the bunker hopper, is a weighing hopper of 20 tons capacity. This is filled with coal and the total weight taken. When an engine is spotted under the weighing hopper, the spout is lowered, the rocking gate opened and the coal dumped on the tender until the engineman signals that enough coal has been delivered. The gates are then closed, the spout raised and the operator weighs the remaining coal. The difference between these two weights is the amount of coal which has been received by the engine. The tickets upon which this information is printed are sent daily to the accountants, who then issue a coal report at the end of the month.

Each weighing hopper is supported on a 30-ton scale, with type-registering beams placed in the weighing house. The poise on the scale beam has a slot into which a card is inserted, and as a lever on the poise is pressed down, the weight is recorded on the card. The scale man in the cabin has control of the weighing apparatus, the levers operating the gates of the storage bunker and weighing hoppers, and the levers operating the coal chutes to the tenders. From his cabin he has a clear view of the tracks.

There are three sand tanks of 10 cu.yd. capacity, supplied with sand from a drier. The delivery spout is adjustable and is protected from rain and sleet. The sand valve is pivoted and of the undercut type, its edges overlapping the discharge openings so that it is sand-tight

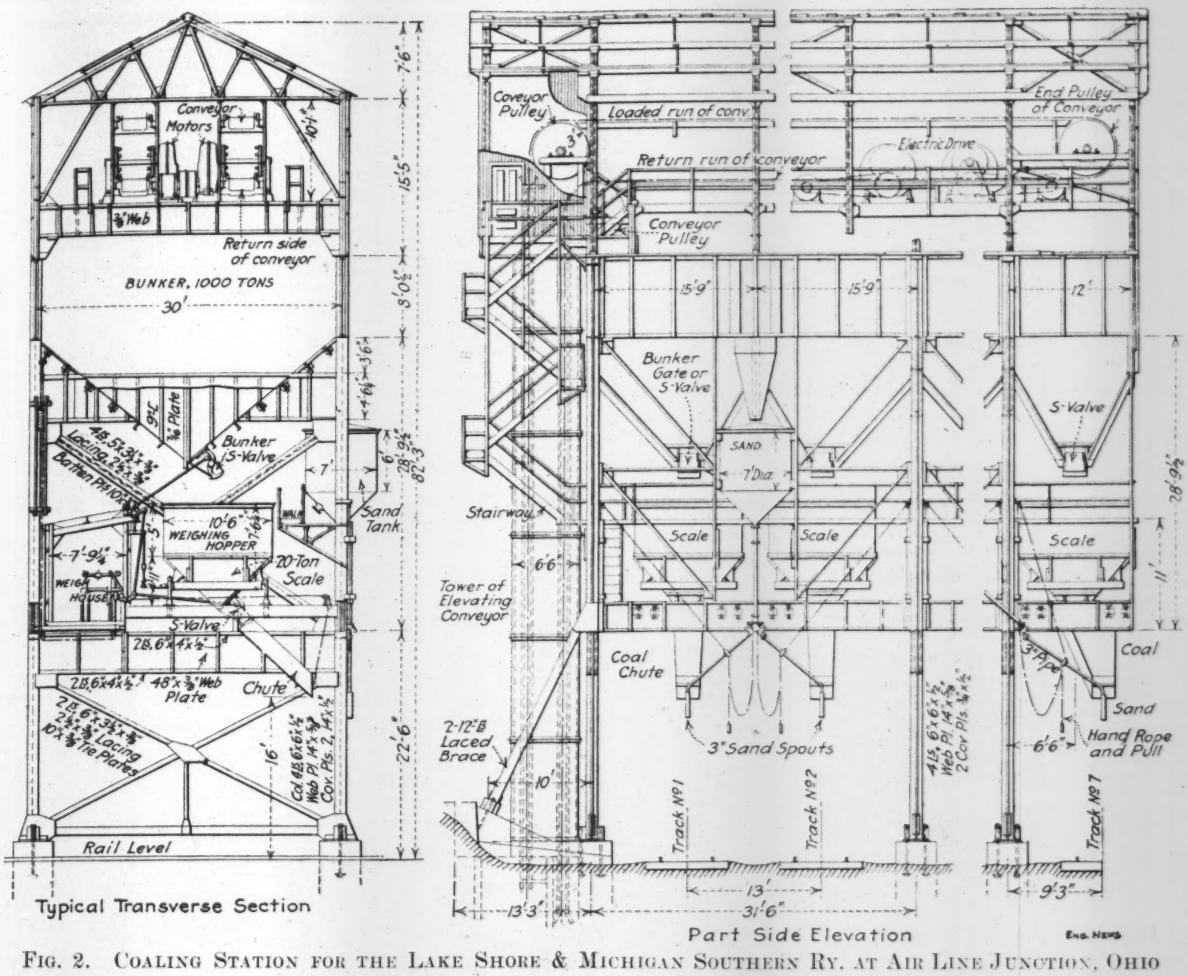


FIG. 2. COALING STATION FOR THE LAKE SHORE & MICHIGAN SOUTHERN RY. AT AIR LINE JUNCTION, OHIO

when closed. The valve and spout are controlled by the fireman on the engine.

This coaling station was designed and built by Phillips, Lang & Co., of Chicago, and its machinery equipment was furnished by the C. W. Hunt Co., of New York. The work was under the general direction of G. C. Cleveland, Chief Engineer of the Lake Shore & Michigan Southern Ry.

Methods of Taking Records of Street Traffic

The following suggestions for a traffic count are abstracted from the report of the Committee on Way, presented at the recent annual meeting of the American Electric Railway Association:

The period to be covered should be 14 consecutive hours, from 5 a.m. to 7 p.m., and during six consecutive or different week days. However, if average weather and traffic conditions are known and selected, the record may cover only three consecutive week days. No traffic should be counted in abnormal weather, such as seasons of snow and ice, nor during continuous rainy, very hot, or excessively cold days, and holidays. The location of the count should be at or near the center of a block and not at any street intersections and traffic both ways must be counted. The observer may be stationed upon the walk, but an elevated position is better and a room facing the street is best.

The general classification of vehicles for practical results is as follows: (1) Horse vehicles; subdivided into one-horse, two-horse, three or more horses; (2) motor vehicles.

The horses as well as the vehicles must be considered in computing weights of traffic from the quantities counted and recorded, because the horse, as well as the vehicle, helps wear the pavement and occupies space. Experience in such counts shows that for general record purposes the average weight of all one-horse vehicles (empty and loaded) can be taken as one ton (2000 lb.); two-horse vehicles as two tons; three or more horse at four tons. Similarly the average of all motor vehicles (empty and loaded) for transportation of persons and goods may be taken at 1¾ tons. Exclude all bicycles, motorcycles and ridden horses.

The record is made on a set of four cardboard slips of different colors, each about 2x9 in., and fastened together by a clip near one end; 14 sets are needed per day, one for each hour. If traffic is extra heavy, more than one set can be used for each hour. Each set is marked for location where count is taken, name of observer, date, hour covered by the set, and the number of standing vehicles. Two observers are required, to relieve one another at the end of each hour, because one recorder cannot work accurately for a longer period.

An ordinary conductor's punch is used and a hole is punched in the proper slip for each vehicle passing in either direction in front of the recorder. One-horse vehicles are punched in the white slip; two-horse in the blue; three- or more horse in the red, and motor vehicles in the yellow slip. Each slip bears a heavy ruled line in the center, lengthwise, and vehicles which are outside of the car tracks are punched above this line and those inside of tracks are punched below the line. A vehicle is to be considered as being in the tracks if the two wheels farthest away from the recorder are on the tracks inside the gage line of the rail nearest the observer.

The number of vehicles standing at curbs is taken generally every two hours, by the relief observer, just prior to the hour, and is recorded on the slips. The number of holes in each slip are not counted until a recorder has stopped observing traffic, either after relief or at the close of the work. The number of holes counted should be written on each slip.

Field and Office

Floating Lock-Gate Lifter for Trent Canal, Canada

The two accompanying views show the new lock-gate lifter which has recently been built for the Department of Railways and Canals of Canada for service on the Trent Canal in Ontario. Its capacity of 50 tons and a clearance above the deck of 37 ft. will enable it to step any of the miter gates on the canal. The machine consists of a structural-steel collapsible derrick mounted on a steel pontoon, with separate steam engines for operating the derrick, lifting the gates and controlling the balancing weights.

The pontoon supporting the derrick is made of steel plating with extra-strong steel framework, there being two longitudinal and three transverse trusses. Its length is 55 ft., beam 27½ ft., and depth 9 ft.

The derrick is hinged at mid-height so that the upper part can be lowered to clear the bridges over the canal.

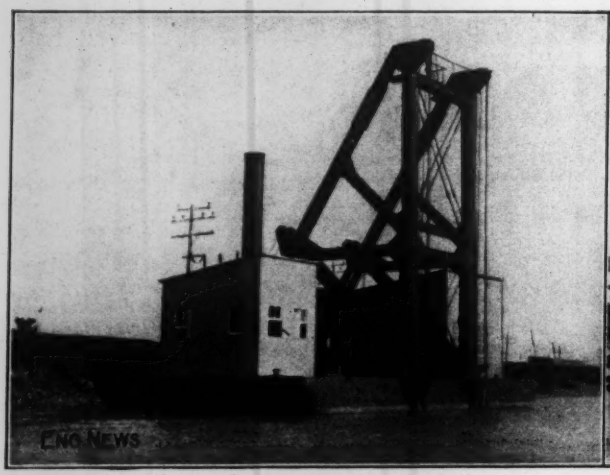


FIG. 1. IN WORKING POSITION

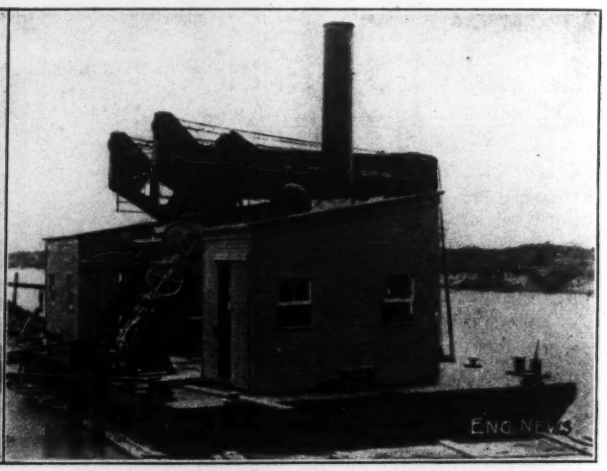


FIG. 2. LOWERED TO CLEAR BRIDGE

FLOATING LOCK-GATE LIFTER FOR TRENT CANAL

Its working position is shown in Fig. 1. In transporting the lifter from one lock to another the upper part is lowered as shown in Fig. 2. The operation of raising and lowering the derrick is controlled by a 6x6-in. double-cylinder engine mounted on one of the back legs (Fig. 2). The gates are lifted through the medium of two swivel hooks which are suspended by ⅞-in. steel cables from the sheaves on the outstanding tops of the front legs of the derrick. This lifting is controlled by a main 9x9-in. double-cylinder engine. The operating levers of all engines are brought to one position for the convenience of the engineer.

The pontoon is kept on an even keel during the lifting process by two movable ballast cars under the deck. Each car is moved by a steel screw operated by an independent engine, which is controlled by pendulum governors automatically shifting the ballast to the proper position to put the pontoon on an even keel. In addition to the automatic control the ballast-car engine can be operated from the engine room above deck. Dial indicators are provided there to show the position of the ballast cars at all times.

The device has been used in stepping the gates on the locks of the Ontario-Rice Lake division of the canal and has met all expectations. The total time for stepping each leaf is 20 min. (upper leaf) to 40 min. (lower leaf).

The machine was built by M. Beatty & Sons, Ltd., of Welland, Ont.

Sediment Test for Water and Other Fluids

BY ROBERT SPURR WESTON*

For some time a simple device has been used successfully for determining the amount of visible sediment in milk. It was suggested by Prof. George C. Whipple, of Harvard University, that this test be applied to waters, especially those containing suspended algae or other plankton, suspended iron, silt, etc.

The method was described by Professor Whipple in connection with a committee report at the annual meeting of the New England Water Works Association, Sept. 8, 1914, and again at the meeting of the American Society of Municipal Improvements on Oct. 6, 1914.

Briefly it consists in straining a measured volume of water (1 gal.) through a disk of cotton felt 25 mm. in diameter and 1 mm. thick. The operation requires but two or three minutes, and the result is a visible record of the coarser suspended matter, which record is far more intelligible to the average mind than any numerical expressions—for example, of "suspended solids," "albuminoid ammonia" or "micro-organisms."

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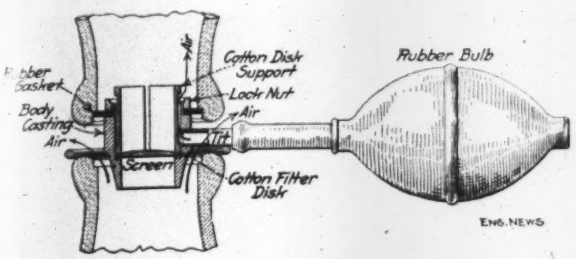


FIG. 1. SEDIMENT TESTER IN POSITION FOR USE

The tester (Fig. 1) consists of a device for holding the cotton disk. The holder has a rubber gasket so that it may be slipped into the cap seat of an ordinary milk bottle. There is a woven-wire screen for supporting the disk in the holder and a rubber bulb for forcing the air into the bottle. After the disk is placed in the holder, it is slipped into the neck of a milk bottle full of water, the bottle is turned upside down and air pumped in to displace the water and force it through the disk.

The disks, after the water has been passed through them, are dried and mounted on sheets of paper.

By determining the sediment in the water at stated intervals, it is possible for any water-works manager to obtain an excellent record of the visible appearance of a water-supply from time to time. It is also very useful in determining the degree of growth of microscopic organisms in various ponds forming the sources of one

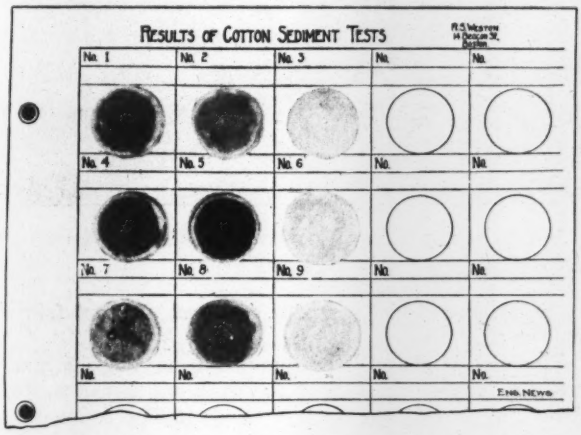


FIG. 2. COTTON DISKS AFTER USE FOR TESTING WATER FOR SEDIMENT

(In the practice of the author, these disks are mounted on blank forms, made up as 8x11-in. loose-leaf sheets. Half of one of these sheets is here reproduced.
The samples were taken from the following sources:
1. Charles River at Cow Bay.
2. Wells, Brookline Water-Works.
3. Experimental filter effluent, Brookline Water-Works.
4. Reservoir, Belfast, Me.
5. Coagulating-basin effluent, Belfast, Me.
6. Filter effluent, Belfast, Me.
7. Reservoir, Exeter, N. H.
8. Coagulating-basin effluent, Exeter, N. H.
9. Filter effluent, Exeter, N. H.
Obviously, the colors of the original are lost in the reproduction. To some extent, the relative shades of the originals have also been lost.)

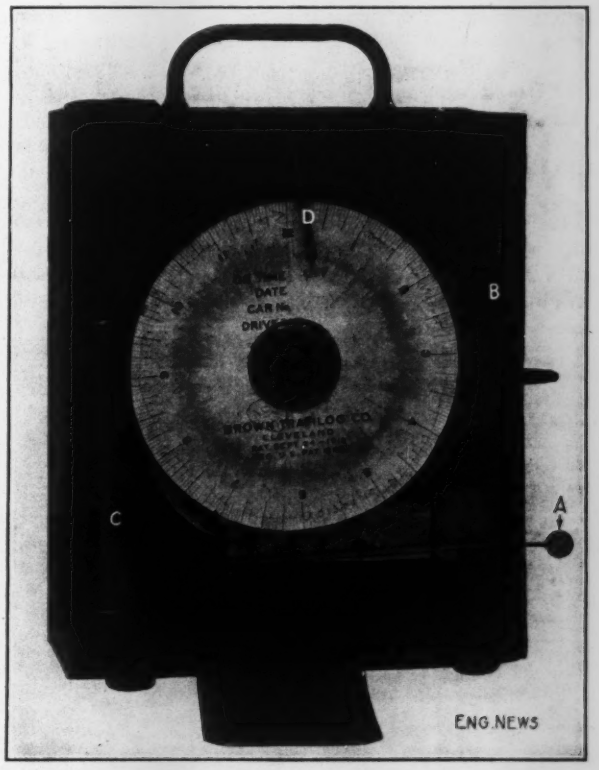
supply; also in determining the relative clearness in different parts of a distribution system, of a water which contains suspended iron rust or silt.

Before the method was published, Professor Whipple suggested its use to the writer, who has made use of it during the past summer with a great deal of satisfaction. Fig. 2 illustrates the results of nine of these tests.

The testing device here described is known as the Wizard Sediment Tester and is made by the Creamery Package Manufacturing Co., of Albany, N. Y. The company also supplies cotton disks for use with the tester.

An Instrument for Recording Roughness of Pavement Surfaces

For the graphic measurement of inequalities in street surfaces, an instrument called the "trafilog," operating on the inertia principle, has been used in Cleveland, Ohio, by a subcommittee of the general good-roads committee called together a few months ago by the Cleveland Chamber of Industry. By attaching this instrument to the floor of a vehicle, charts are obtained containing records of the riding qualities of the streets traversed.



THE "TRAFILOG," AN INSTRUMENT FOR RECORDING THE ROUGHNESS OF PAVEMENT SURFACES

To explain the accompanying illustration, the button *A* on the right is for starting and stopping the rotation of the chart. The chart is mounted on a disk and driven by a clock train. The lower horizontal arm is one of a pair of parallel links which support the clock movement. The movement is counterbalanced by a flat-leaf spring, *B*, a curved part of which is seen on the right. On the left is an oil dashpot *C* for damping the oscillation. The marker *D* has a jewel stylus which scratches the surface of the chart. The chart is a specially prepared paper with a white coating over a dark base.

The body of the instrument is poised so that a circumferential mark is drawn on the face of the chart by the clock movement; a vertical line is made when a wheel of the vehicle drops into a rut. When it comes out of the rut or strikes a hump, the direction of the line is reversed. The length of the mark is proportional to the depth of the rut, and the abruptness of the lines indicates the nature of its edges. There is no provision to take care of vibration or record lateral swings of the vehicle.

The instrument is set on the floor of the vehicle and held down by the observer's foot resting on the base plate, although for convenience on extended runs the instrument is mounted on a bracket in front of the observer. The instrument was devised by W. H. Brown, and is made by the Brown Trafilog Co., Rose Bldg., Cleveland, Ohio.

Removing Subway Excavation Spoil with Portable Bucket Elevators

Portable bucket elevators are being used on Section 3, Division 7, of the new 7th Ave. subway on Greenwich St., near Reade St., New York City, to lift excavated dirt to the street. With this type of machine, large street openings are unnecessary, as the standard 24-in. manhole is utilized by snubbing the bucket chain by means of an idler shown in Fig. 1.

The elevator, illustrated in Fig. 1, is self-contained and consists of a timber frame, chain and buckets, motor and driving mechanism, and boot. The buckets are 8x5 in. and spaced 18 in. in the clear. The outfits can handle

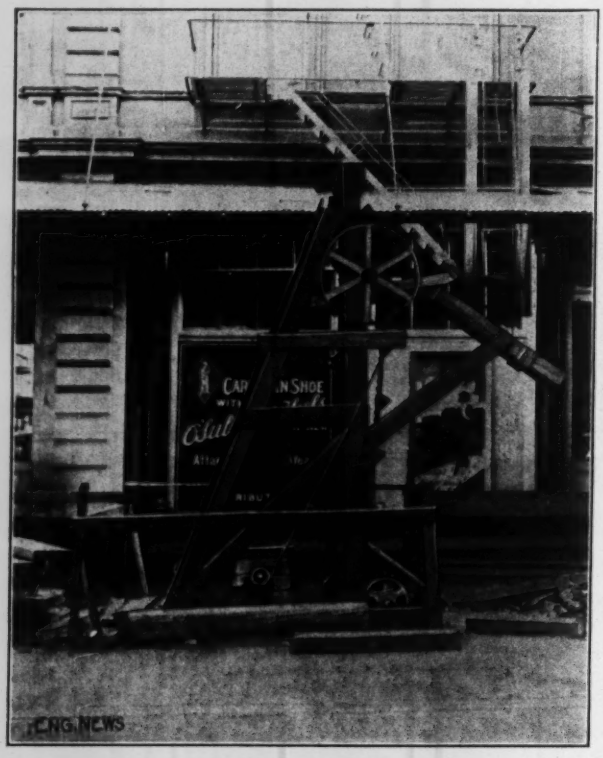


FIG. 1. A PORTABLE BUCKET ELEVATOR ON SUBWAY EXCAVATION IN NEW YORK

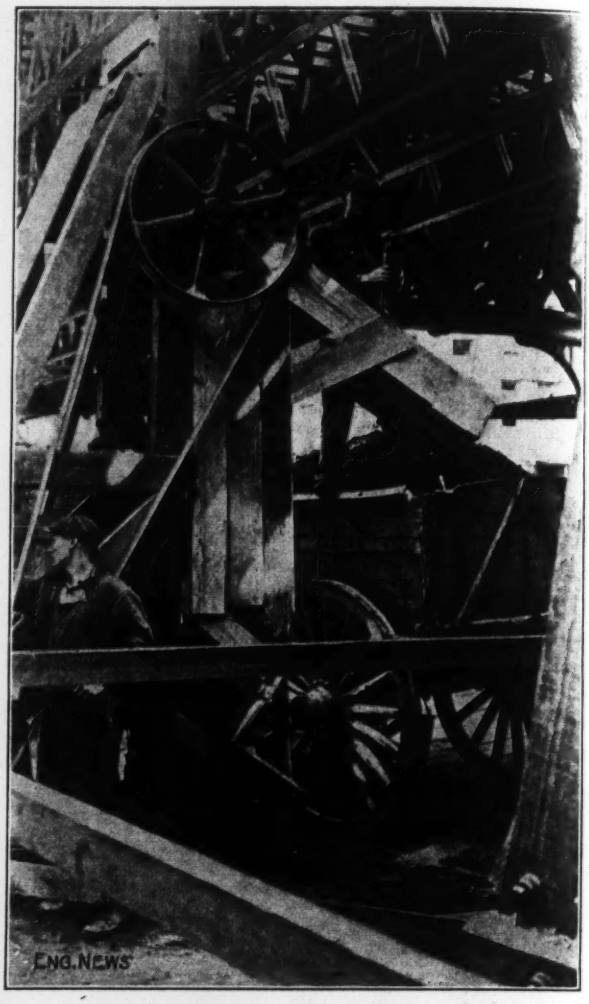


FIG. 2. CART BEING LOADED FROM CHUTE FED BY BUCKETS

15 to 20 tons of dirt per hour each and are kept fairly busy on this job.

The dirt is shoveled or dumped from wheelbarrows into the boot at the foot of the conveyor, lifted to the street and chuted into carts, as shown in Fig. 2. A cart is loaded in 10 to 15 min.

When the digging has progressed sufficiently to make it desirable to move the elevator to a new location, the chain (which is of the griplock type) is removed from the sprockets in the boot and hauled up on the framework. The whole is then moved where desired. The boot is too large to pass through a manhole, so is moved along under the street surface. Manholes are located about 100 ft. apart.

The Degnon Contracting Co. has four of these bucket elevators in operation at the location named. They were furnished by the Robins Conveying Belt Co.

The Efficiency of Clamps on Tie-Rods in forms for concrete work is illustrated by an experience in the building of 18-in. concrete walls 16 ft. high for a flour mill at Detroit. Under the thrust of the wet concrete the forms bulged, and the tie-rods broke instead of pulling through the clamps, which were of the Universal design, described in our issue of Sept. 10.

Calibrating Some Venturi Meters for Air Flow

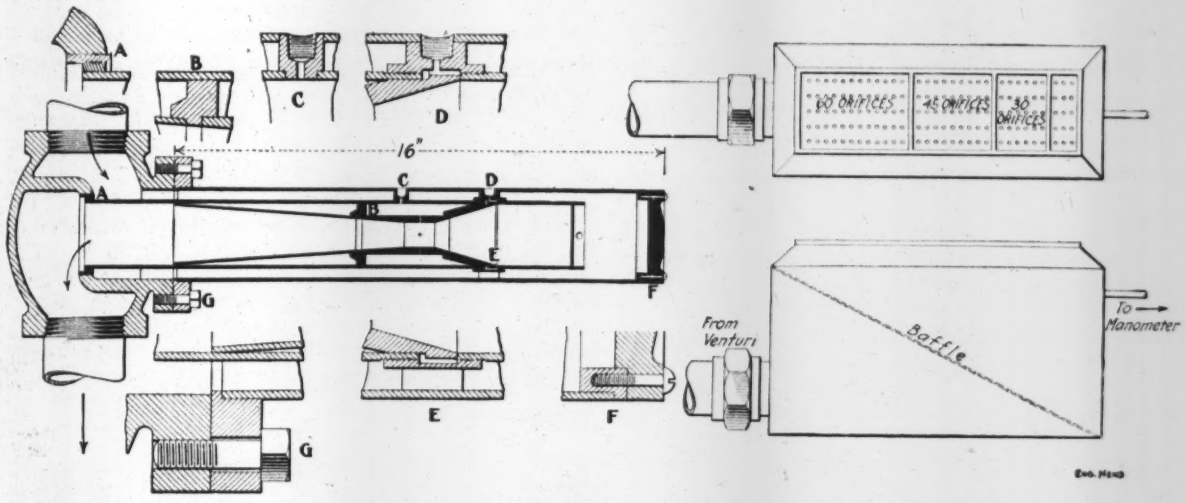
In the design of the Brooklyn Sewage Experiment Station under Geo. T. Hammond, Engineer of Sewer Design, Bureau of Sewers, Brooklyn, N. Y., one of the troublesome problems was in securing a meter for the compressed-air lines. On account of the quantity of air used and the pressure, no form of available gas meter was found to meet the requirements. Therefore, special Venturi meters were designed jointly by Mr. Hammond and Wallace & Tiernan, of New York City. Interest attaches first to the method of calibration and only somewhat less to the details of the meters.

CALIBRATION—The calibration method is of unusual interest and wide application. On account of the quantity of air flowing, it was impractical to use a gasometer for calibrating the meter. Therefore, a special multiple-orifice box was built to receive and measure the air passing through the meter. The top of the box was a metal plate having, in all, 150 orifices of the same size (punched with the same die) equally spaced. This top plate had a cover so arranged that any number of orifices from 1 to 150 might be left open. The orifices were designed to discharge 1 cu.ft. per min., under a head of 10 in. water pressure. A perforated metal screen, placed diagonally across the box, prevented eddy currents. Preliminary readings were made with a small gasometer to determine the air flows from different orifices (for rating the calibration box) and from different groups of orifices to see if there was any variation because of location or number of those discharging. It was found that the flows agreed within ½%.

In calibrating a meter, the box was connected to the air line through the meter and a certain number of orifices were uncovered on the top of the box, a stop valve being opened until the desired head was shown on the box manometer. Knowing the discharge for this number of orifices and the corresponding pressure, it was a simple matter to mark on the Venturi-manometer scale the flow corresponding to the height of liquid. The scale was then fully graduated in cubic feet per minute after having determined several of these points.

VENTURI METERS—The specifications, according to which the Venturis were made, called for three sets of meters; one reading from 20 to 150 cu.ft. per min., one from 5 to 20 cu.ft., and a third from 1 to 30—all operating under a pressure of about 40 lb. per sq.in. In order to secure the desired range with accuracy a type was designed with interchangeable throats. To secure accuracy through the range indicated, five meters would ordinarily be employed. Such multiplicity was ingeniously obviated in this case. The meters were assembled in tubes of the same size so that any one could be screwed into the body of an ordinary 3-in. check valve put in the air line. There were three barrels complete, with Venturi throats, etc., for each meter. Two of these three barrels were of small capacity and each had interchangeable throats, while the third was larger and had but one throat.

Air passes from the check valve (following the arrow in the upper left of the section of the meter shown in the accompanying drawing) along the meter barrel, through the throat and out through the air line again.



VENTURI METER FOR AIR FLOW AND MULTIPLE-ORIFICE CALIBRATING BOX

To put in a larger or smaller throat giving the desired capacity, the barrel cap is removed, the approach tube screwed out of its bushing, and the throat approach and throat taken out. Without displacing further parts, the smaller or larger throat is inserted. All parts were made of brass and bronze.

The manometer intended for use with these Venturis was of special design. The cross-section of the oil reservoir was made many times greater than that of the manometer tube, so that the zero point was practically unaffected through the range of the scale. The upper end of the manometer tube, which was connected to the Venturi throat chamber, had a reservoir interposed of capacity slightly greater than that of the lower reservoir. This was done to prevent blowing any of the oil into the pipe line by sudden rushes of air.

It may be added that these meters are used to measure compressed air supplied in experiments on the aëration of sewage. The entire equipment of the Brooklyn Sewage Experiment Station was described in ENGINEERING NEWS, Oct. 22, 1914. The same issue contained a short article on the calibrated orifices for controlling sewage flow at the station just named.

A Contractor's Coal Scow with Portable Motor

In dredging ditches and an outlet from a lake for purposes of drainage, the contractor found difficulty in getting fuel to the dredge. The shore being of very soft soil, he could not haul the coal near the work, but was compelled to unload it at a road crossing and one other point where the high land came near the ditch, and it was necessary at times to carry it in a scow for about two miles to the dredge.

A Contractor's Scow Fitted with a Portable Motor and Carrying 8 Tons of Coal to a Dredge

The machine requires 5½ tons of coal per day and has storage capacity for 30 tons. The plan is to handle one 8-ton load daily until the bunkers are full, and then wait a day, or if the weather is bad two days may be missed.

The coal scow is 12x18 ft., 28 in. deep, and carries about 8 tons. It is slow and difficult work to navigate it by hand, the ditch being 48 ft. wide on top and 14 ft. deep. The contractor therefore purchased a portable marine motor of 3½ hp., made by the Evinrude Motor Co., of Milwaukee, Wis. With this a speed of 4 m.p.h. is made, while the scow is easily handled. This loaded motor scow is shown in the accompanying cut. The motor has a frame hooked over the stern of the boat and carries a little gasoline motor at the head of a vertical shaft, geared to the short propeller shaft at its lower end. No rudder is required, the propeller being shifted to steer the boat.

The same motor is used on the scow which carries the men from the house-boat to the dredge. When the house-boat is to be moved, it is towed by the empty coal scow. The adoption of this device enables the contractor to use roughly made and cheap barges, which will stand the rough handling, and yet have the advantages of power equipment and save the expense of a gasoline launch for towing.

The work is in Emmet County, Iowa, and the contractor is D. C. Stephens. For information we are indebted to H. B. Whitney, manager for the contractor, Hippee Building, Des Moines, Iowa.

Novel Method of Trench Excavation

By J. C. Lathrop*

The accompanying views illustrate a novel method used by the Ault Construction Co. in excavating a trench for a water main installed by the city of Baltimore, near Clifton Park. The main is of reinforced-concrete pipe, with an inside diameter of 7 ft., the shell being 7 in. thick. The pipe sections are 6 ft. long and were cast in a yard near one end of the trench. The length of the trench dug by the Ault Construction Co. was about 1700 ft. The average depth was 15 ft., varying from 12 ft. at one end, to 20 ft. at the other, while the width was 13 ft.

The method used in trenching is plainly shown in the accompanying illustrations. A dragline bucket with a capacity of 22 cu.ft. was pulled up an incline by an

*Baltimore, Md.

Fig. 1. Incline and Dumping Tower for Dragline Excavator

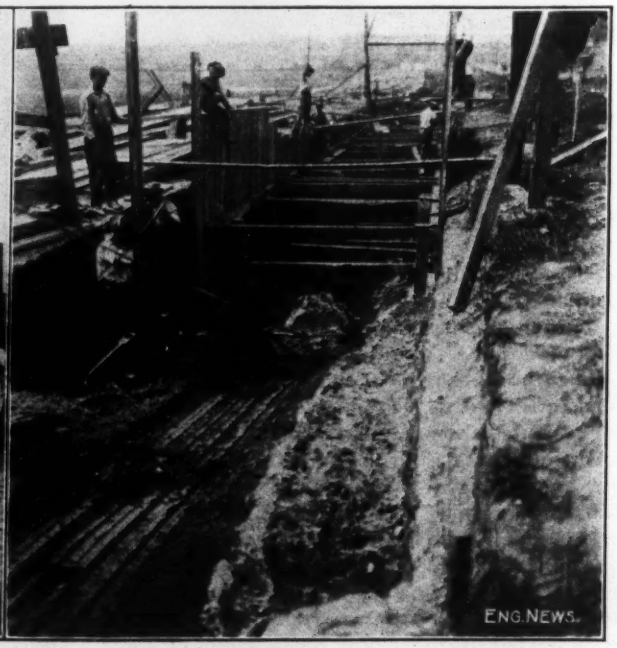


Fig. 2. Dragline Excavator for Sewer Trenching

ordinary contractor's engine and dumped into a hopper which delivered the earth to carts or wagons.

The total amount of earth removed by this method was approximately 13,000 cu.yd., one-quarter of which was hauled away to allow for the space occupied by the pipe. The balance was piled up at one side of the trench to form an embankment, upon which was placed track for a locomotive and locomotive crane to handle the concrete pipe sections.

The essential reason for adopting this scheme of excavation instead of a steam shovel was that, owing to the character of the material, the banks would not stand without supports. It was found necessary to carry down 2-in. sheeting as the excavation proceeded. Waling strips 6x8 in., about 16 ft. long, were held in place by vertical 6x8-in. timbers, which were cross-braced at the top and intermediate points by other 6x8-in. timbers. At the bottom of the trench 6x8-in. timbers were placed at intervals, so spaced that they would come directly under the joints of the concrete pipe. Concrete was placed under the pipe and between the timbers to prevent settlement.

The sheeting was driven by two small steam hammers, which were carried by block and falls hung from steel cables directly over each line of sheeting. Steam for these hammers was taken from the boiler which supplied the hoisting engine. The capacity of this boiler being insufficient, its output was supplemented by that from a traction engine.

This work proceeded rapidly, as high as 250 scoopfuls being removed in one working day, which means an average of a round trip in two minutes. The sheeting and bracing were carried along simultaneously.

The Ault Construction Co. has another contract for a similar trench in which the material is all solid rock which has to be blasted. They are using a similar device for removing this material.

WHAT IS GRAVEL?

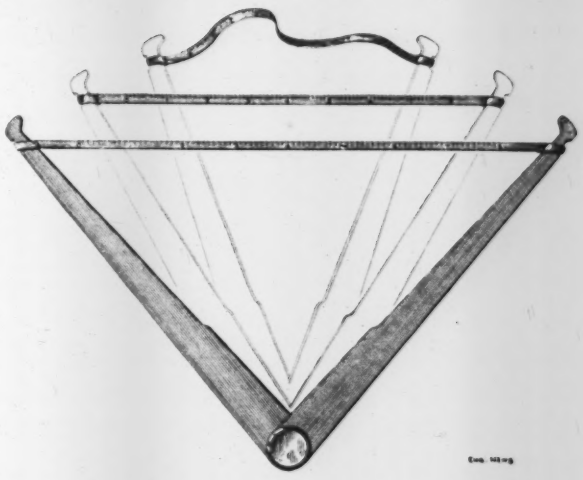
A concise and clear definition of gravel is desired by manufacturers of machinery for excavating and handling this material. What maximum size, proportion and character of stones mark the line between gravel and boulders, when (for instance) a machine is guaranteed for handling "gravel." The dictionary definitions are not sufficiently clear and explicit to meet the requirements of the case. Probably many of our readers have encountered this problem in different ways, as in the classification of material for excavation, and we shall be glad to have their views in the matter.

NOTES

An Ingenious Proportional Scale—Something new in the way of proportional scales for measuring or transferring dimensions has been worked out by F. J. Winters, draftsman, New York City, for use in his own work. The device is sketched herewith. A piece of narrow elastic webbing is stretched between the points of a pair of firm-joint straight-leg calipers. A scale is inked on this webbing, and by changing the spread of the calipers this scale is stretched or shortened to suit the needs of the case.

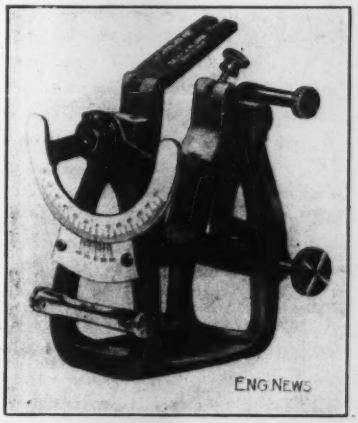
Whoever has experienced the bother of trying to read dimensions from a drawing which contains possibly half a dozen different-scale sketches will appreciate this device. The device proves especially useful when the scale of a drawing is not given, but a particular dimension is shown, as, say, 7 ft. 10¼ in., in which case there is some difficulty in finding the scale of the drawing in the ordinary way, while with this proportional device the proper setting is made instantly.

In inking the scale on the elastic band—which is simply narrow elastic hat tape of best quality about $\frac{3}{16}$ in. wide—the markings are made when the band is stretched out. They must be made with a fine-pointed brush dipped in India ink, as a pen will pull the tape out of line and falsify the dimensions or markings. When the band is let go, the marks become fine and sharp. The chief difficulty with this device is that the tape does not retain its proportionality of stretch in the different parts of its length more than three or four months, when a new band must be put on. For those who have much proportional measuring to do, it is of such value that even the frequent replacement of the measuring band is no great objection.



AN INGENIOUS PROPORTIONAL SCALE

A Wye-Level with Transit Attachment—A new type of surveying instrument has recently been put on the market which combines a 12-in. architect's wye-level with a transit attachment. Obviously the transit is not intended for accurate survey work, for the horizontal and vertical circles read only to 5′. It does answer, however, for laying out buildings and similar work, while used as a wye-level it has much greater accuracy than a cheap transit; and accuracy in leveling is an important factor in the work for which the instrument is designed. The instrument is built like an ordinary wye-level except that it has a horizontal circle below the level bar. In the center of the level bar is a threaded hole into which fits a thumbscrew for fastening on a transit attachment (shown in accompanying illustration) consisting of telescope standards, a 50° vertical arc, reading to 5′, and a level vial. The level telescope is mounted in these standards and the instrument is ready for use as a transit. The instrument is made by Geier & Bluhm, Troy, N. Y., and is listed, complete with tripod and accessories, at $60. The transit attachment alone is listed at $10, and can be made to fit any architect's level.

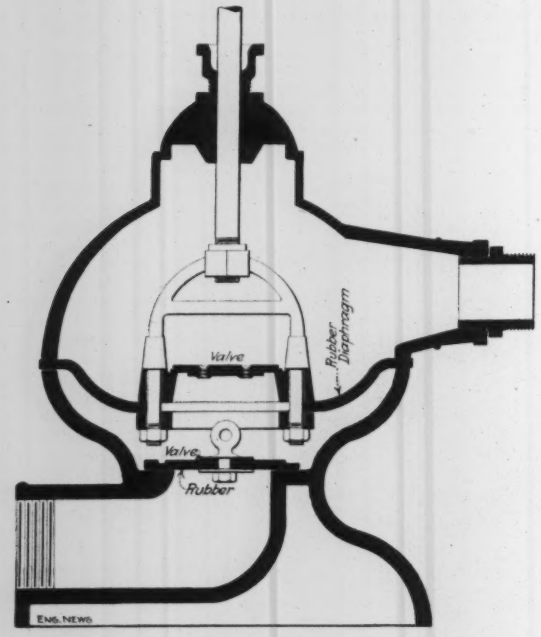


TRANSIT ATTACHMENT FOR AN ARCHITECT'S WYE-LEVEL

A Method of Interpolating Slope-Stakes on Uneven Ground—I had occasion recently to run a survey line crossing a number of small drains, diagonally. The ridges between were not high, approximately 15 ft., and the distance from ridge to ridge varied from 100 to 250 ft. The profile of the line was to be a balanced one, and the side slopes were to be carefully done to give a good appearance, and were to be sodded. To secure nice, even slopes, I realized at once that

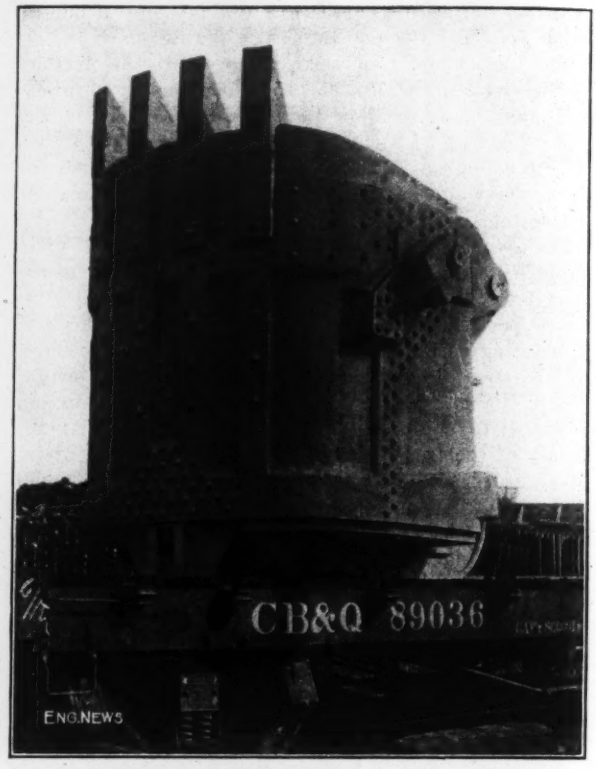
the more slope-stakes used, the more accurate would be the tops of the slopes, at least; and as the slope is dressed from the top down, this would govern the whole. I set the slope-stakes on the ridges close enough for quantity purposes. I then used three sight rods, each with a small triangular block of wood clamped on temporarily; the angle of the block being such that when the rod was inclined to fit 1½ on 1 slope, the top of the block would be level. I set one of these rods at a slope-stake, sinking the rod in the earth solid enough to hold it in position, and at the same time inclining it until a small pocket-level laid on the triangular block indicated that the rod had the proper slope. I did the same with another rod at the next slope-stake. The third rod I had one of the men place in the proper inclined position as indicated by the level on the back of the rod and in contact with a string extending between the two grounded rods set at the slope-stakes. The string should be on the same side of all three rods; but may be at the top of one rod, at the middle of another, and at the bottom of the third. By this means, I staked out the top of the slope of cuts with stakes set at as frequent an interval as the nature of the ground required The results are fine, there being no guesswork in starting the slope. In staking out the base of fills on uneven ground the same plan can be used, only the rods must be inclined in the opposite direction. This method of course cannot be used on curves.—S. P. Baird, Engineer and Contractor, 315 West Ninth Ave., Columbus, Ohio.

Injecting Grout with Diaphragm Pumps—In place of grouting by compresed air, the common way, some Boston contractors do their grouting with diaphragm pumps, successfully. The Hugh Nawn Contracting Co. used such pumps extensively on the Boston subway work. They found compressed-air grouting unsatisfactory for the work they were doing on the Boylston St. subway, and subsequently did the work with a hand-operated diaphragm pump of the Edson Mfg. Co. In using the pump for more than a year, no difficulties of moment developed; clogging did not give trouble. New valve linings and new rubber diaphragms had to be put in about once in three months. The sketch herewith shows such a pump in cross-section. Coleman Bros., of Boston, have also used these pumps for cement grouting.



Sketch Section of Edson Pump, Used for Grouting by Hugh Nawn Contracting Co.

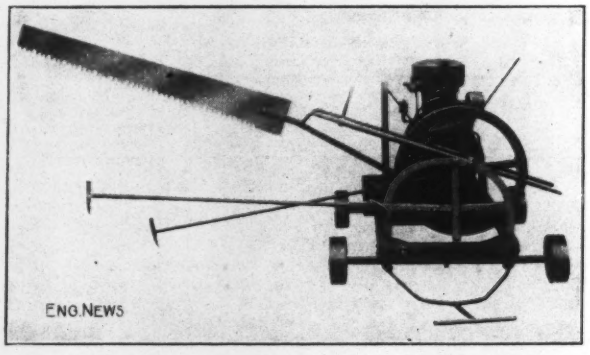
Manganese-Steel Dipper Buckets for Panama Dredges—The accompanying view shows an 18-ton dredge dipper made of cast manganese-steel. Its capacity is 10 cu-yd. Two of these dippers were recently fitted to the Panama Canal dredges "Paraiso" and "Gamboa." The overall dimensions are 10½x 9x9 ft. The lips of the dippers are 3¼ in. thick; the fronts are 3¼ in. thick underneath the teeth, 1½ in. between the teeth and 3¼ in. thick at the bottom band; the backs are 1¼ in. thick at the sides and 3¼ in. thick at the bottom bands.



Manganese-Steel Dipper for Panama Dredges

The body of the dipper consists of a front and a back casting, with lap-riveted joints at the side. In addition, the lip is a separate casting riveted to the front piece and additionally joined thereto by the rivets of the tooth ribs. The dippers are of the "Missabe" type, made by the Edgar Allen American Manganese Steel Co. for the Bucyrus Co. This type has been used on 3-yd. and 5-yd. steam shovels, but has not been applied to larger sizes before the present instance.

Fast Work with a Power Saw for Construction Timbers—A new gasoline-engine crosscut saw rig built by the Whitman Agricultural Co. recently made a good 10-hr. run, during which 14x14-in. timbers were cut in 60 sec. each. The gasoline consumption per day was so low as to be negligible. The power element is a 2½-hp. "Sultan" engine, with clutch and gear transmission to the saw crankwheel. A hand truck carries the whole machine, so that the machine is taken to the timber instead of taking the timber to the saw. Dogs for holding the work are pivoted to the frame. The clutch allows throwing the saw out of action instantly. For falsework construction, this saw rig ought to prove widely useful.



Gasoline-Power Portable Saw for Construction Timbers

Editorials

The Mechanical Engineer in Municipal Engineering

A notable and unprecedented feature of the coming annual meeting of the American Society of Mechanical Engineers, to be held in New York City during the first week in December, is the devoting of one entire day to papers and discussions on the general subject of municipal engineering. It has hitherto been generally accepted that city engineering work was matter with which the civil engineers had solely to do. Such work as city surveying, paving and sewerage are well recognized as belonging to the civil engineer, primarily. On the other hand, other functions which are becoming more and more prominent in the administration of cities at the present day, such as electric lighting, street railways, treatment of garbage and refuse, necessarily bring in the mechanical engineer to a large extent.

The mechanical engineer, moreover, is laying claim to be considered as an administrator as well as a technical employee. In the broad field of administrative work, the engineer needs, of course, a general grasp of professional knowledge rather than special details. The engineer appointed as a city's general manager, for example, must, through his subordinates, deal with every aspect of municipal work, from the laying out of street grades to the purification of the boiler water-supply in a power station. There need be no jealousy or rivalry, therefore, between the civil and mechanical branches of the profession in municipal engineering work, and in fact a number of those who are on the program for papers at the Mechanical Engineers' Convention on Municipal Day are prominent civil engineers. What is the most important consideration of all is that such an emphasis by a public meeting of the engineer's part in carrying on city administration cannot but have a useful effect in the formation of public opinion as to the value of the engineer's service in the municipal field.

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Continuing Activity in the Building Industry

The returns made to ENGINEERING NEWS by the building departments of 17 Eastern cities of the building permits issued for the month of October show a falling off of only 8% in the total value of buildings for which plans were filed during that month as compared with October of 1913. In 20 cities of the Middle West there is a considerably larger falling off, but it is not uniform, and some cities, such as Cleveland, Columbus, Des Moines, Duluth and St. Louis, report more building plans filed last month than in October, 1913.

This is the most notable evidence of returning business confidence and the revival of prosperity that has anywhere appeared. It is a far better index of what may be expected in the near future than any record of current business transactions in the iron and steel market or the clearing-house exchanges. It shows that a large proportion of real-estate owners have confidence enough in the future to carry on work previously planned to the stage of actual construction. It may be assumed where plans are filed for a building that arrangements have been completed for financing its construction. It means, furthermore, that the people who are putting up these buildings believe that the times will be prosperous enough when these buildings are completed, six months to a year hence, so that tenants will be then found for the dwellings and apartments and stores. Moreover, the lists of new buildings include some factories. Certain lines of manufacturing, the woolen industry for example, have been so active during the last few months that they are forced to enlarge their facilities for production. This is most cheerful news to come at a time when even the professional optimist has a hard struggle to maintain his reputation.

⁂

Handling Materials on Highway Construction

The fact that road building has been the most active branch of construction work carried on extensively during the past year or two, probably explains why many construction firms whose previous experience has been in railway construction have turned to highway contracting. With them into this work the railway builders have brought methods and equipment, which have gone far to raise the status of the highway contractor. For, while a few years ago the average road contractor was an enterprising farmer or labor foreman, using teams hired by the day from the neighboring farmers, the present-day ex-railway contractor uses an industrial railway, or tractors and dump wagons, or motor trucks, for hauling his materials.

Which of these three new methods to use is always a problem to be solved by many considerations, based on topography, railway service, character of the highways, and many more elements which must be known and studied in advance if the most economical solution is to be made. Perhaps, however, the most interesting development in the solution of this many-sided problem is the apparent increase in popularity of the industrial railway. These are being used successfully on roads having grades as high as 7 or 8%, with the help of pusher engines.

Motor trucks and tractors generally have to navigate some pretty rough going, which is always the case when the new road, torn up in advance of pavement laying, is the only access to the work, for if the hauling is done from the other end, the traffic of the tractors and trucks is not good for the newly made pavement.

On the other hand, the narrow-gage railway laid on one side of the roadway may be so placed as to be seldom or never disturbed, and furnishes ready access to all parts of the work, before, during and after construction. Moreover, small cars on rails are generally easier to handle than heavy dump wagons and traction engines, while

motor trucks have the disadvantage of wasting considerable time and capital while being held at the terminal point for loading.

Like all construction problems, this is one that cannot be decided offhand in the office; but the possibilities of the industrial railway for construction work of all kinds is often not appreciated by contractors who have never had experience in railway building.

Where the highway right-of-way is wide enough and has fairly level grades, a contractor might go even a step farther and extend standard-gage tracks to the work, thus avoiding any rehandling of the materials whatsoever. Another possibility is the use of trolley tracks or temporary extensions of trolley tracks.

The Panama Canal and the Transcontinental Railways

During the quarter century since the construction of a transoceanic canal across the Central American Isthmus became a live issue, a vast deal has been printed regarding the effect of such a canal upon the transcontinental railways. It has been very generally assumed that the canal would be a serious detriment to these railways on the one hand, and on the other that its construction would be particularly advantageous to the states on the Pacific coast to relieve them from the alleged exorbitant freight charges of the railways from the East. In recent years, however, a saner view has gradually gained ground, and it has come to be realized by those closest to the problem that the amount of railway traffic which the canal will affect and which will be diverted to the canal will be, after all, comparatively small. Further, it is seen that the stimulating effect upon certain lines of traffic and business resulting from the canal will have in all probability some compensating benefits for the railways.

Some attention is given to this matter in the annual report of the Northern Pacific Railroad Co., just issued. The report says:

> The bulk of the traffic moving into and out of the ports on either ocean starts from or is destined for the country's great interior. The main lines of the Northern Pacific at the head of Lake Superior to Puget Sound are more than 1900 miles in length, [but] the average haul of a ton of freight on the company's railways last year was only 275 miles.

These figures indicate how comparatively small is the percentage of the freight traffic which moves from coast to coast. A considerable part of this traffic also will be carried by the railways notwithstanding the existence of the canal route. For certain high-class merchandise it will be cheaper to pay a somewhat higher freight rate and have the shipment go through by rail in a week or less, rather than incur the delay of nearly a month required for the voyage from a north Pacific port to a north Atlantic port through the Panama Canal.

An Explanation of the Autoclave Test for Cement

Since the recrudescence, some two years ago, of the high-pressure accelerated test of the soundness of cement, named by its promoter the "autoclave test," engineers have looked in vain for any good explanation of why a cement which proved quite sound under the ordinary boiling test would show decided unsoundness under the high pressure and temperature of the autoclave. The failure of the opponents of the test to furnish any adequate explanation of this phenomenon was undoubtedly the main reason why many were ready to accept the claims of the autoclave adherents, although these claims were often injudiciously advanced and pressed.

In the U. S. Bureau of Standards "Notes" in the *Journal* of the Franklin Institute, November, 1914, Messrs. A. A. Klein and A. J. Phillips present an abstract of a study on the hydration of portland cement, in which are included three paragraphs which, if not an explanation, are at least an interpretation of the frequently observed behavior of cement in the autoclave. The paragraphs follow:

> On the hydration of cement, the first constituent to react is the aluminate, with the formation of amorphous hydrated tricalcium aluminate, with or without amorphous hydrated alumina. The sulpho-aluminate crystals are also formed, and the low-burned or finely ground lime hydrates. This occurs within a few hours after the cement is gaged. The next compound to hydrate is the tri-calcium silicate. This commences within 24 hr., and is generally completely hydrated within 7 days. Between 7 and 28 days, the amorphous aluminate commences to crystallize and the beta-ortho-silicate, the least reactive compound, begins to hydrate. The 24-hr. strengths are due mainly to the hydration of the aluminates and of any fine-grained, low-burned lime present. The large increase in strength between 24 hr. and 7 days is due mainly to the tricalcium silicate hydration. The increase between 7 and 28 days is due to the hydration of the beta-ortho-silicate. Where there is a decrease in strength during this period it is due to the hydration of very high-burned free lime, as in very high-burned, high-limed cements, or to the crystallization of the aluminates, as in high-alumina cements.
>
> Failure of cement in accelerated tests is due to the growth of large lime hydrate crystals. The disrupting action results from the pressure caused by growing crystals. Cement will fail in the boiling test which contains lime sufficiently fine and high burned, so that during boiling it hydrates and crystallizes. The growth of crystals is sufficient to cause disintegration. When a cement passes the boiling test but not the autoclave test, it contains lime so coarse or high burned as not to hydrate in the boiling test, but only in the autoclave, due to the high temperature and pressure employed. Some cements will pass either test only after aging. In this case aëration with insufficient water to allow solution and crystallization causes the lime to hydrate as amorphous hydrate, and in the accelerated tests there is no crystallization and no disintegration.
>
> The reactions when cement is subjected to the autoclave test are not abnormal. The disintegration action attributed to the crystallization of the sulpho-aluminate has been greatly exaggerated.

It remains now for someone to show just how the "coarse or high burned" lime is sufficiently active under normal conditions to be a menace to concrete in structures.

Accurate Marksmanship in Naval Warfare

Engineers who have had occasion to become familiar with naval matters are aware of the wonderful precision in marksmanship that has been attained during the past dozen years in the leading navies of the world. It has been claimed, however, that the high perfection of marksmanship attained in target practice in time of peace could not possibly be approached under the excitement of a battle. The recent naval engagement off the coast of Chile, however, appears to be a marvelous illustration of what can be actually accomplished by a fighting ship at long range. According to the newspaper reports of the combat, the German cruisers began firing at their English antagonists at a distance of six miles, and had inflicted serious injuries upon them by the time this distance was reduced to four miles.

In a circle of six miles radius, the length of one minute of arc is approximately 9 ft. A gun trained on the center of a vessel 400 ft. long at a distance of 6 miles, therefore, if rotated only 22 minutes in the horizontal plane, would miss the vessel entirely, and a much shorter distance of rotation would cause it to miss the vital portions of the vessel. If, however, the vessel were approaching, bows on, or fleeing, with her stern toward the adversary, a cruiser of 60-ft. beam would cover less than 7 minutes of arc on the circle, so that a horizontal rotation of the gun of only three minutes from the center of the target would cause it to miss.

Of course, this takes into consideration only the mathematics of the problem. Other factors which may disturb the true flight of the projectile, such as inaccuracies in the gun, or in the projectile itself, influences of the wind, etc., and inaccuracies in the telescopic sighting instruments, have to be taken into account. Incredible though this astonishing accuracy in directing an enormous cannon, weighing many tons, may appear to the layman, it seems insignificant when compared with the difficulties of training the gun in elevation. The same figures, of course, hold good for the same range. That is, an elevation or depression of one minute of the gun about its horizontal axis will make a difference of 9 ft. in the point struck by the projectile six miles away. War vessels have usually a comparatively low freeboard, so that an error in the elevation of the gun of 1½ to 2 minutes may be sufficient to cause the shot to miss its mark. The accurate pointing of the gun, moreover, must be done not from a stationary platform but on board a ship which may be pitching and rolling. All reports agree that the recent battle off the coast of Chile took place in a severe storm, approaching a hurricane in violence.

The latest reports, in fact, claim that the largest English vessel engaged was unable to use a large part of her battery on account of her heavy roll before she had received severe injuries from her adversaries.

The engineer takes off his hat, metaphorically speaking, to "the man behind the gun," whose wonderful skill and careful use of his instruments achieve such results. But these results are also a testimonial to the marvelous accuracy of modern methods of manufacture, which can produce a gun capable of such close shooting. The modern high-power rifle may almost be compared to an astronomical instrument in the accuracy of its workmanship; but while the astronomical instrument is carefully protected against stresses which might interfere with its accurate work, the gun and its mounting are subjected to enormous stresses and shocks, notwithstanding which it must maintain its accuracy unimpaired.

Letters to the Editor

On the Thickness of Pavement Foundations for Heavy Traffic

Sir—Your correspondents in discussing pavement foundations have, I think, entirely missed the essential point and that is: An increase in the thickness of paving foundations over present American practice is a necessity as a protection to wearing surfaces and not to the base itself. A concrete foundation does not need to be badly fractured or shattered to be a failure in this sense; it is in the wearing surface that we must look for foundation failures.

The following are some of the reasons why heavy traffic streets in our cities should have pavement foundations thicker than 6 in.:

(1) The concrete in the base is not uniform in mixture or thickness, and, as laid in the street, its strength falls much below its theoretical value. The thinner it is laid the greater percentage of loss through dirt mixing with the bottom portion of the concrete, the subgrade soaking up the cement and water, and the greater the chances of rock pockets being formed. Even under the most rigid inspection, it is impossible and impractical to avoid these defects.

(2) If it were always possible to detect all the soft spots in the subgrade before the foundation is placed, the idea of thickening the concrete over them might work out. However, our city business streets have been so badly cut up that it is as cheap to thicken the whole base as it is to dig out each cut. Worst of all, the surface of the subgrade may appear uniformly compact and later develop many sunken spots, due to the bottom of an old trench settling, to leaky sewers or service connections or leaky water pipes.

(3) Temperature changes are greater in, and more seriously affect, a thin base than a thick one.

(4) Each wheel of a loaded vehicle is the center of an area of depression which is of considerable extent. The base is not rigidly supported at any point and the maximum deflection may be very appreciable without fracturing the concrete. This will vary with the condition of the soil and subgrade, width of street, weight of load, kind of surfacing and depth of foundation.

The amount of deflection for a given load has been measured by the U. S. Bureau of Standards on various kinds of pavement, and is appreciable on new cement-grouted stone block on 6 in. of portland-cement concrete base, and is very considerable on asphalt laid on a 4-in. base, or in the best forms of bituminous macadam. It is also probable that a cement-grouted brick surfacing, for instance, does not bend on the same curve as the base.

At any rate, the passage of a moving load is accompanied by a series of waves or undulations in the wearing surface, and in my opinion, this deflection or waving is great enough to seriously affect the wearing surface of a pavement subjected to the passage of large numbers of heavy vehicles, when the pavement is laid on a base of 6 in. or less of 1:3:6 concrete.

While such a statement may appear to be finely drawn, it is to be remembered that the effect of one load must

be multiplied by the hundreds for each day and extended over a period of several years.

Owing to the numerous factors acting on the wearing surface, it is difficult to determine the effect of deflection except by comparing pavements subjected to similar conditions, but with different bases, over a period of years. The principle may be laid down that the more rigid the base, the more nearly the wearing surface can be maintained to an exactly uniform grade, and thus be more enduring. Greater rigidity can be obtained more economically by increased thickness.

(5) The speed at which motor trucks move over streets demands a more massive foundation than one 6 in. thick. Loads moving over stone block, brick, manholes on a worn hard-rubber tire cause slight impact blows which are so rapidly repeated under a swiftly moving load that series of vibrations are set up in the pavement.

Where the pavement is slightly rough and on a thin foundation, these vibrations can be felt for some distance and are even carried through the earth to near-by structures. These vibrations are evidently a detriment to block pavements and must also affect the sheet surfacings.

A massive foundation will absorb these shocks. The more severe impacts where a heavy load drops into a slight depression, off a high manhole or car track, soon shatter the base as well as the wearing surface. Such a condition, however, is generally due to faulty subgrade or construction.

In answer to the editorial inquiry as to the effect of impact on paving foundations, probably no base of good concrete 6 in. thick on a good subgrade is shattered where the wearing surface is maintained in good condition. I have seen weaker bases broken up where the surfacing had been allowed to deteriorate.

Impact does, however, seriously affect the wearing surface. Asphalt has practically no cushioning effect after it has been compacted by traffic and during the nine cool months of the year. The block pavements on sand cushions do relieve the foundation by their cushioning and load-distributing effects.

(6) A review of the increase in wheel loads and traffic conditions on city streets during the past 15 years, as well as the great amount of poor or repaired pavement, should cause municipal engineers to look forward.

While one of your correspondents advises heavy rails, closely spaced ties, and 18 in. of solid concrete under and around the ties of street-car tracks to absorb vibrations and prevent shattering of the pavement, he mentions a 6-in. foundation under the street pavement as a "wise precaution."

The fact of the matter is that motor-truck wheel loads are closely approaching street-car wheel loads in amount and a motor truck does not run along a smooth steel rail, but is allowed any place on a more or less uneven surface. A pavement foundation which theoretically should be good for 30 to 50 years ought to be designed with the future in mind.

To protect our expensive wearing surface from needless wear and tear, to maintain smooth, easy riding pavements, to lessen the frequency, expense and inconvenience of repairs, let us provide more rigid, more massive pavement foundations on the heavy-traffic streets than has been customary. No specified thickness can be universal but make 10 or 12 in. the maximum rather than 6 in.

CLARK R. MANDIGO,
Assistant City Engineer.
Kansas City, Mo., Oct. 28, 1914.

Broken Sprinkler Connections at the Salem Fire

Sir—The statements in the paper by Frank A. McInnes and Clarence Goldsmith, read before the New England Water Works Association at the recent meeting in Boston, Mass., with regard to the effect of broken sprinkler connections on the water pressure, are not altogether in accord with the facts. [See abstract, ENG. NEWS, Oct. 22, 1914.]

The breakage of the public water connection to the two sprinklered risks spoken of did not occur until about 3:30 p.m., nearly two hours after the fire started. And this breakage did not begin the demoralization of the fire-fighting service; that began one hour and forty-five minutes before. According to the report of competent engineers, the first fire company to get into action had to retire almost immediately. Another company tried to connect up a chuck hydrant a block away and finding it defective, had to beat a retreat. In the meantime, the fire burned without the least restraint. The day was hot and dry and the heat radiated by the fire was fearful. These conditions, of course, resulted in the opening of hundreds of sprinklers in the Keefe and Carr tanneries and they did not open in vain. These sprinklers contested the progress of the fire in the Keefe and Carr factories for a considerable period. The attack of the fire on these factories began between 1:49 and 1:55 p.m., and the riser pipes did not fall until about 3:30 p.m.

The authors of the paper overlooked the fact that there were many connections with the public water service other than the sprinkler connections. Five tanneries and leather plants were burned in Blubber Hollow. Two of them were sprinklered. All of them used water, particularly the tanneries—and tanneries use considerable water. These plants had regular service connections, some of them possibly as large as 6 in. These connections were independent of the sprinkler connections and added much to the wastage.

It is obviously stretching the imagination to charge that the difference between 8585 gal. and 2500 gal. per min. is due to broken sprinkler connections when numerous cascades from various broken and melted connections were to be seen after the fire had swept on its way.

Moreover, it is difficult to reconcile the statement that 2500 gal. per min. was the limit of the amount of water pumped when there were 25 steam- and gasoline-pumping engines at work in various sections of the city.

Other and competent engineers estimated that the maximum water consumption during the fire was at the rate of 17,700 gal. per min.

And what is more, the low pressures—the minimum was 10 lb. for one hour—were not the sole result of broken sprinkler connections. In a report on the Salem fire, Franklin H. Wentworth, Secretary of the National Fire Protection Association, says:

The abundant water-supplies of Peabody, Danvers and Beverly were gingerly tied into the Salem system in fear that the pressure they had to contribute would shatter Salem's obsolete old mains and end the water throwing for

flood. With water enough to raft Salem out to sea, her citizens on the borders of the fire zone threw away their garden hose and extinguished the sparks on their shingle roofs with tree-spraying outfits.

In the report of the Inspection Department of the Associated Factory Mutual Fire Insurance Companies is this comment:

There was apparently some hesitancy about turning in the higher pressures from surrounding towns until it was apparent that there was sufficient draft from the Salem mains so that the pressure would not build up.

Broken sprinkler connections should not be the "bone of contention" regarding the Salem fire. To be sure they broke and wasted water, but that was not a "lesson" of the Salem fire. The desirability of positive control of connections between public water-service mains and sprinkler systems in buildings cannot be gainsaid, but the arguments for this desirability cannot be strengthened by the happenings in Salem, for the building in which the fire began was not equipped with sprinklers and the pressure began to drop an hour and a half before the sprinkler connections broke. And the conflagration was burning blocks beyond the Carr and Keefe plants when the connections did break.

The one thing in the Salem water system reported excellent by the National Board of Engineers in 1907 was the spacing of gate valves. Why was it that an engineer of an organization of fire-insurance companies had to direct the closing of the sprinkler-connection valve at the Carr plant at 5 p.m., one hour and a half after the sprinkler risers went down? Surely there must have been valves in the public mains outside the fire zone which could have been closed.

Inspector Ames in his report to the Underwriters' Bureau of New England said: "*There was no time when the steamers lacked a water-supply.*" Evidently the breaks in the sprinkler-system connections did not hopelessly cripple the water service. And if the broken sprinkler systems had been immediately shut off and the pressure restored to normal conditions, what then? Franklin Wentworth answers the question: "Water from hose streams never yet stopped nor extinguished a conflagration."

And the fact will bear repeating that there would not have been any sprinkler-system breaks to talk about if the Korn factory had been equipped with automatic sprinklers.

I. G. HOAGLAND,
Secretary National Automatic Sprinkler Association.
80 Maiden Lane, New York City,
Oct. 26, 1914.

[Proof of Mr. Hoagland's letter was submitted to Messrs. McInnes and Goldsmith. Their reply follows.—EDITOR.]

Sir—In reply to the foregoing letter from I. G. Hoagland, we would say that our paper was written after an exhaustive study of the conditions obtaining during the first hour of the fire, the period with which we dealt. The officers of every engine company, numerous firemen and a number of others from whom reliable information could be had were interviewed. Information thus obtained was tabulated and only that which was corroborated by several witnesses was accepted.

Our data show conclusively that the three sprinkler pipes in question were broken within the first hour. If the evidence to this effect was not convincing it is inconceivable that buildings of so flimsy construction could survive for an hour under such exposure. Even if the buildings had remained standing and the pipes were unbroken, the systems would have discharged practically the same quantity of water through open sprinkler heads with equally disastrous effect.

Information was obtained in regard to all large service connections within the entire burnt area, and the only one broken in the area covered by the fire within the first hour was a single 2-in. The effect of the other services broken in this area was almost negligible.

We were not forced to exercise our imagination as the facts established by the test were sufficient to prove our point.

At the end of the first hour, ten engines only were at work and our information is conclusive that 2500 gal. per min. is a conservative estimate of their delivery. The figure used by Mr. Hoagland, namely, 17,700 gal. per min., represents the maximum draft during the fire and includes the waste from broken connections, steamer supply and domestic consumption. The fact that the minimum pressure of 10 lb. was not reached until the fire had been in progress nine hours is evidence of the large amount of water wasted.

The assumption that the waste through the three broken connections could have been stopped by closing valves in the public mains outside the fire zone evidences unfamiliarity with water-works systems and their operation.

If this could have been done it would have been necessary to close eight gates, two of which were on the large main feeding the district, with the result that the supply would not only have been withdrawn from many engines then working, but the entire western end of the city would have been without water-supply.

The writers were present during the height of the conflagration and were eyewitnesses to the fact that a considerable area of the city was entirely without water and that the engines even at the lower elevations were seriously handicapped on account of lack of pressure.

We are absolutely of the opinion that the flow of water through the connections to the Keefe and Carr plants practically destroyed the efficiency of the Salem water-works system, and are convinced that the size of such connections should be carefully restricted.

F. A. MCINNES,
CLARENCE GOLDSMITH.

City Hall, Boston, Mass.,
Nov. 6, 1914.

NOTES AND QUERIES

In the plan accompanying the retaining-wall failure described on p. 894 of our issue of Oct. 29, 1914, the direction indicated by the arrow as north is in reality west.

E. A. Little is Superintendent of the Engineering & Construction Department, United States Realty & Improvement Co., instead of R. K. Smith, as mentioned on p. 885 of our issue of Oct. 29.

An Employment Department has been established by the American Institute of Electrical Engineers. It is proposed to publish, in the monthly proceedings, announcements of positions open, records of men available, etc.

The Road Congress at Atlanta

The fourth annual Road Congress, conducted by the American Highway Association and allied organizations at Atlanta last week, attracted the largest attendance, probably, of any meeting for the discussion of highway improvement ever held in this country.

A large proportion of those at the sessions were county commissioners and county engineers from Georgia and other Southern states; but there was also a large attendance of state highway engineers and city engineers in charge of street paving from every part of the country from New England to California.

At previous Congresses, agitation for Federal appropriations to build good roads has loomed large in the proceedings. This year the Federal aid question was kept in the background. At the afternoon session on the first day, which was supposed to be devoted to this topic, the Shackleford Federal Aid bill, which passed the House last spring but failed in the Senate, was generally condemned. On account of present and prospective financial conditions, it is generally realized that any considerable Federal appropriations for road construction are unlikely for some time to come.

A matter which figured more prominently in the Congress than Federal aid was the question whether state funds for road work should be expended on through routes or on radial roads from cities into the country to enable the farmers to reach a market. It is noteworthy that Fairfax Harrison, President of the Southern Ry., who was elected President of the American Highway Association at this meeting, presented a paper on Wednesday in which he declared that the first roads to be improved should be the roads connecting the farmer with the railway shipping point and the market and not the through routes so much desired by the automobile interests.

The Tuesday afternoon session was conducted by the National Civil Service Reform League and was intended to further the merit system in road organizations. The Chairman, Hon. R. H. Dana, and the speakers, Geo. R. Wales, Chief Examiner of the U. S. Civil Service Commission, and Arthur M. Swanson, Chief Examiner of the Philadelphia Civil Service Commission, vigorously supported the policy of selecting candidates by Civil Service methods for high appointive positions as well as for the lower positions.

Strong emphasis was laid by many speakers at different sessions on the desirability of supervising all the road work in a state through a state highway department. All but eight states have now in operation some form of state supervision, and these eight states, all in the South, are likely to create state highway departments next year.

A score or more of papers on various aspects of road construction and maintenance were read at the convention, and with the discussion upon them (of which the crowded program gave time for very little) will be later published in the Congress proceedings. Of these, the most interesting and valuable to highway engineers generally was probably the paper by Col. Sohier, Chairman of the Massachusetts Highway Commission, giving detailed figures as to the cost of road maintenance in Massachusetts, and also in England and France. An abstract of this appears elsewhere in this issue. Another paper dealing largely with foreign practice was by Henry W. Durham, Chief Engineer of Highways of the Borough of Manhattan. Both these papers furnish most useful ammunition to the American engineer beset by a critic who holds the common idea that American engineers are fatally deficient in not copying foreign practice in street and road construction and maintenance.

The use of convict labor on public roads was a prominent subject in several papers before the convention, notably one by Geo. P. Coleman, State Highway Commissioner of Virginia, where 1700 convicts are worked on the roads the year round.

It is of interest to note that the emphasis in the good-road agitation which has been hitherto laid on road construction is now laid on road maintenance. Various speakers at the Congress urged that unless a large part of the money spent on road construction is to be wholly wasted, there must be first created an efficient organization which will see to it that the construction is done honestly and economically and that the completed road is continuously maintained.

The resolutions adopted by the Congress set forth that state-road departments and state aid are necessary to secure economy in highway construction; commend the work of the Lincoln Highway Association; recommend greater attention to the public safety by road officials; and urge that the Federal government undertake the construction of highways across forest and Indian reservations where necessary to provide links in through roads.

Road Maintenance Costs in France, England and Massachusetts*

By William D. Sohier†

French Roads

The French road system was established in 1826, and the total road system of 371,000 miles was built in about the next 25 years. The roads, practically uniform except as to width, have been built almost entirely of local macadam originally, 6 or 8 in. deep on a proper foundation. In resurfacing some of the main roads in later years, a harder stone and Welsh or Belgian granite have been used. The macadam surface of the road on the Routes nationales is 24 ft.; Routes departmentales, 18 ft., and the Routes de grande communication and d'interet commun, 15 ft.

The French engineers last spring estimated that some 8000 miles of road ought to be resurfaced, using a tar macadam, because of the large increase in automobile travel around the cities, which travel was rapidly destroying their macadam roads, and they requested the Government to furnish $60,000,000 for that purpose, about $7500 a mile. The greatest problem for over fifty years has been maintenance. The roads are maintained practically by a central organization. The whole country is divided into 86 departments, and all of the county and rural roads within the department are managed by the prefet of that department and the expenditures appropriated by the council.

Direct charge is in the hands of a centralized body of competent engineers, about half of whom are graduates of the National School. Each department is divided into

*Portion of paper entitled "Road Maintenance," read before American Road Congress, Atlanta, Ga., Nov. 9-14, 1914.

†Chairman, Massachusetts Highway Commission, Boston, Mass.

four or five political districts, each district being called an arrondissement, and the roads are in charge of a district engineer, who is under the direction of the chief engineer. Each arrondissement is again divided into districts or cantons, and an assistant road engineer under the direction of the district road engineer looks after all the county and rural roads within the canton. Then comes the final subdivision, where the roads are divided into sections of a few miles long, taken care of by patrolmen. All of these are under civil service, and the men are promoted from time to time according to their ability.

Table I gives the approximate cost of maintenance on the French roads annually.

TABLE I. MAINTENANCE COSTS OF FRENCH ROADS

	Miles		Total Expense	Per Mile
Routes Nationales	23,800		$6,500,000	$273
Routes Departmentales	8,100	115,400	1,500,000	185
Chemins vicinaux				
Routes de grande communication	107,300		16,900,000	157
Route d'interet commun	47,500		6,000,000	126
Routes ordinaires	184,700		14,500,000	78

English Roads

In 1878 the cost of main roads was placed upon the counties. In order to even up the expense more or less the English government made appropriations to aid in the maintenance of these main roads, beginning in 1882 with an appropriation of about $800,000. In 1888 about $2,500,000 was appropriated, and now the Road Board has something over $6,000,000 annually which can be spent in improving the main roads. There is now a combination of the county taking care of the urban and rural main roads, with the parish and local authorities taking care of the rural roads. The main roads are something over 20% of all the mileage, leaving out London.

In almost all of the counties there are sections of road in charge of regular maintenance men. Most of the main roads in England outside of Metropolitan London and the other large cities are maintained by the use of tar. Some 40,000 miles of road were tarred in England last year, and some 6500 miles were built of tarred macadam. The system of maintenance now is not only to keep the roads constantly patched, but every year or twice a year the macadam roads are flushed and rolled, filling the holes and depressions first and adding a small quantity of chips and stone dust. On the tarred roads a section man keeps them constantly patched. They usually require a fifth or a sixth of a gallon of tar which is sprayed on once a year, and this is covered with pea stone or gravel and kept covered so it will not pick up. The tar is usually sprayed on under power.

Where there is heavy traffic the roads are being resurfaced with tarred Welsh granite, which is like our trap rock, or with tarmac, which is a tarred iron slag. There is also built a road of 3-in. stone, rolled hard, and grouted with a mixture of hot sand and hot tar, equal volume, poured into the road until it flushes it; then rolled in 1½-in. stone and smaller stone with a surface coat of tar and sand. The macadam roads with a tarred surface require retreatment every year. This costs about 2½ to 3c. per sq.yd. a year. The tar-mix roads require a new coat of a fifth of a gallon of tar applied on the surface every two years.

Average costs of road maintenance are given in Table II.

Maintenance of State Highways in Massachusetts

Our Commission began building roads in 1894. The earlier roads were almost entirely macadam with a few miles of gravel or graded road. The standard road with necessary foundation and proper drainage wherever necessary was 15 ft. in width, water-bound macadam either of trap or local stone, 6 in. deep in the center and 4 in. on the sides, with a 3-ft. gravel shoulder on each side and with a ¾-in. crown to the foot.

TABLE II. ROAD MAINTENANCE COSTS IN ENGLAND

	Miles	Maintenance	Authorities County Engineers	Yearly maintenance per mile
County Councils:				
Urban main roads	4,189	$4,601,790	61	$1100
Rural main roads	23,565	10,177,740		431
	27,754	$14,779,530		
County Boroughs	9,366	$6,437,380	28	$685
London Authorities	2,192	3,691,355	2	1680
	11,558	$10,128,735	30	
			Road Authorities	
Urban roads	11,411	$4,848,020	1733	$425
Urban roads	4,871	2,701,710		555
Rural roads	95,077	$11,562,920		122
	111,359	$19,112,650		
Totals	150,671	$44,020,915	1898	$290

The total expenditures per year, including improvements and interest, $75,990,000

The ordinary cost of maintenance is in Table IV, but up to 1907, when some of the roads were 12 years old, the cost of ordinary maintenance was substantially $100 a mile a year. Ordinary maintenance with us consisted merely of keeping the gutters, catch basins and drainage open and clean, cutting out the grass and brush on the roadsides, keeping the shoulders in proper condition, spreading a little gravel or sand on the road surface from time to time and filling the few holes or ruts that might occur with broken stone or gravel. Very few miles of road has been actually resurfaced prior to 1907.

In 1906, the automobiles began to come. Our roads were some of them 13 years old and only half the original depth of stone was left. We soon found that automobile travel, especially at high speed, tore up the macadam or gravel roads, especially on the curves, as soon as there were any considerable number, say 50 or more in a day. The traffic, of course, increased tremendously in the number of vehicles, because of the large mileage of the automobiles. What had been locally used country roads developed, between that year and the present year, into main through routes carrying oftentimes away out in the country on a main route over one thousand cars a day. Table III shows the increase in traffic from 1909 to 1912.

TABLE III. TRAFFIC CENSUS, 1909 AND 1912, MASSACHUSETTS

	1909 Census, 238.5 Stations			1912 Census, 156.5 Stations			
Kind of Vehicle	Av. Total No. per Day	Av. No. per Day per Sta.	% of No. per Sta.	Av. Total No. per Day	Av. No. per Day per Sta.	% of No. per Sta.	Inc. or Dec. %
Motors							
Runabouts	4,958.5	20.8	8.5	5,819.0	37.2	11	+79
Touring cars	17,950.5	75.3	30.5	27,178.5	173.5	49	+130
Trucks	.....	.....	....	1,800.0	11.5	3	.....
Total motors	22,909.0	96.1	39.0	34,797.5	222.2	63	+131
Horse-drawn vehicles:							
1-horse, light	17,033.0	71.5	29.0	8,380.0	53.5	15	—25
1-horse, heavy	11,762.5	49.3	20.0	7,458.0	47.6	14	—3
2 or more horses, light	1,006.0	4.2	2.0	556.0	3.6	1	—14
2 or more horses, heavy	6,205.5	26.0	10.0	3,870.5	24.7	7	—5
Total horse-drawn	36,007.0	151.0	61.0	20,264.5	129.4	37	—14
Totals of all kinds	.....	247.1	.....	.....	351.6	..	+42

Table IV gives maintenance charges of the state highways of Massachusetts from 1894 to 1913.

Starting in 1907 it will be noted that the cost for maintenance has risen by leaps and bounds from $158 a mile a year in 1907 to over $850 a mile a year in 1913, and it is still higher in 1914.

Our roads were rapidly going to pieces. We needed more money. We got the Legislature to double its ap-

propriation of $100,000 a year and make it $250,000 for one year and $200,000 a year since. We secured an increase in the automobile fees, and had four-fifths of that money available for the maintenance of state highways, and the other one-fifth for the improvement or maintenance of through routes in the towns. We found that our old roads were being destroyed by the rapidly increasing amount of automobile travel. The traffic on the roads had increased from 10 to 40 times in volume.

TABLE IV. COST FOR REPAIR AND MAINTENANCE OF STATE HIGHWAYS, FROM 1894 TO 1913, MASSACHUSETTS

	Repair and Maintenance			State Highways	
Year	Cost	Miles	Av. Cost per Mile per Year	Miles Laid Out	Cost of Construction
1894	.....	.....		39.88	.....
1895	.....	.....		50.03	$637,847
1896	$4,727	89.10	$53.05	37.02	458,581
1897	13,267	126.01	105.28	53.25	482,076
1898	20,661	179.26	115.26	42.63	490,783
1899	24,538	221.94	110.56	44.56	407,309
1900	33,562	266.50	125.93	49.40	396,450
1901	31,061	315.90	98.32	61.68	453,826
1902	58,943	377.58	158.75	53.32	466,743
1903	55,033	430.90	127.83	74.17	445,972
1904	51,896	505.03	102.76	60.85	445,745
1905	57,456	565.88	101.53	56.53	509,007
1906	68,382	622.45	109.86	47.92	444,655
1907	106,189	670.37	158.40	39.33	467,944
1908	147,037 82,628*	709.70	323.47	38.40	564,719
1909	247,985 154,131*	748.27	537.39	36.53	431,814
1910	214,561 289,498*	784.80	642.28	52.80	462,165
1911	213,476 316,603*	837.59	632.86	42.00	412,542
1912	208,687 414,407*	879.59	708.39	40.72	366,424
1913	203,762 595,185*	920.31	868.13	60.06	909,063
				980.88	$9,262,674

	Per Mile per Yr.
Average cost of repair and maintenance, 1895–1907, incl.	$105
Average cost of repair and maintenance, 1908–1913, incl.	619
Average cost of repair and maintenance, 1895–1913, incl.	267

*Motor Vehicle Fees Fund.

Today, nine-tenths of all our state highways that have not been resurfaced have been coated and kept coated with some bituminous material and have been kept constantly patched. Where heavy hot oil was used, it has lasted in some instances for five years, carrying a large amount of automobile travel but a small amount of heavy teaming. Under many heavy teams it has failed in a month or two. We have then used a light oil to lay the dust and prevent the automobiles from tearing the road up, and have left the stone to carry the travel until we could resurface the road.

Because of the automobile traffic on many main routes, we are now using in our resurfacing a bituminous top 2 to 3 in. deep. We have used refined tars by both the mixing and grouting method. We have used asphalts with the same methods, and we believe that use is economical and necessary on any roads that have more than fifty automobiles a day and where there are more than fifty loaded teams.

In Table V is shown the class and character of surfaced roads that we believe will stand traffic of a certain class, kind and character.

Certain exceptions to Table V should be noted. Army maneuvers, especially large bodies of cavalry and artillery, will rapidly destroy any bituminous blanket surface. A blanket coat of hot oil on macadam will carry a much larger number of teams if there is a ratio of two to three automobiles on pneumatic tires to each team to keep the bituminous surface constantly rolled down when the horses and teams pick it up. A very few teams on narrow tires or a few very heavy teams every day will destroy the surface if the load is heavy enough to shear down

TABLE V. COMPARATIVE VALUE OF ROAD SURFACES

(Results of observations of traffic on different types of road surfaces in Massachusetts—Standard Road, 15 ft. in width, gravel or waterbound macadam 5 to 6 in. in thickness, with adequate drainage and proper foundation, with 3 ft. gravel shoulder on each side.)

	AVERAGE DAILY TRAFFIC			
	Light Teams—Carriages, Wagons	Heavy Teams, 1-Horse	Heavy Teams 2 or more Horses	Automobiles
A good gravel road will wear reasonably well and be economical with	50–75	25–30	10–15	50 to 75
Needs to be oiled with	50–75	25–30	10–15	Over 75
Oiled gravel, fairly good, heavy, cold oil, ½ gal. to the sq.yd., applied annually with	75–100	30–50	20	500 to 700 or more
Waterbound macadam will stand with	175–200	175–200	60–80	Not over 50 at high speed
Cold oil or tar will prove serviceable on such macadam with	175–200	175–200	60–80	50-500
Macadam will then stand but the stone wears, of course, with	175–200	175–200	60–80	500 or more
Waterbound macadam with hot asphaltic oil blanket will be economical with	100–150	50–75	25–30	1500 and more with fewer teams
And stand at least	.....	.....	.....	50 trucks
But will crumble and perhaps fail with over (On narrow tires, ice, farm and wood teams, etc.)	150	75	30	
Waterbound macadam with a good surface coating of tar (½ gal. to the sq.yd.) will stand with	100–150	50–75	25–30	1500 or more
but requires to be recoated annually with ¼ gal. of tar per sq.yd.				

It is assumed that all road surfaces are kept constantly patched, that before applying bitumen the road surface is cleaned and patched, and the bitumen covered with pea stone and sand or gravel and kept covered so that it never picks up.

entirely through the surface to the stone. If this process is repeated once or twice a day, a rut soon develops and the road becomes muddy and the bituminous surface rapidly disintegrated.

Ordinary maintenance, which has consisted of keeping the drainage open, shoulders cut back, and the road sanded, with slight patching, has averaged about $100 a mile a year. Where the road can be maintained with light oil, the additional cost is about $250 a mile a year, or $350 a mile a year in all. The cost of heavy oil or tar on the surface where it is suitable to use it because it will stand the traffic, is about twice the cost of the light oil in the first instance, and with the patching and all that is necessary it will cost about the same figure, or about $250 to $300 a mile a year, this being on a five-year basis.

In resurfacing our roads with 2- to 3-in. bituminous macadam top, the cost has varied from about 50c. per sq.yd. for a 1½-in. top, no stone being larger than 1¼ in., and 1¼ gal. of tar sprayed into it, to $1.10 a sq.yd. for a 3-in. top, made of 2½-in. stone, either mixed or grouted with a good grade of asphalt. The tar-sand grouted macadam has cost from 90c. to $1 per sq.yd. We believe that the roads of this character will have a very small maintenance cost outside of the ordinary maintenance for a period of from eight to twelve years.

Lack of Uniformity in Notation is the cause of no little trouble to engineers in studying theoretical problems. One phase of this question was recently discussed as follows by a speaker before the Concrete Institute in London:

One of the greatest causes of difference in notation is the blind copying of symbols by persons who really do not know what is the origin of a given symbol; in fact, it has been suggested by some brilliant student that people only used algebraic symbols when they did not know what they were talking about, and there certainly seems a great deal of truth in that remark. Another cause of the growth of chaos and deterioration of notations, is that when books are translated from a foreign language, it may be that the author is not a mathematician—he may be merely a linguist; for he frequently translates the words and leaves the letters in their original form, and the books lose a great deal of their utility. I would ask that if books are to be translated they should be translated by engineers, or by mathematicians, or by competent persons able to convert one notation into the other.

Emil Kuichling

By Allen Hazen*

Emil Kuichling died suddenly in New York City, Nov. 9, of apoplexy. Although he had lived in New York City for the last fifteen years and much of his best known work had been done there, yet his memory will always be associated with Rochester. In his long previous residence in Rochester, his connection with the water-supply and sewerage systems of that city, first, as Assistant in the Water Department for twelve years, then as a member of the Executive Board for two years, and, after an interval, as Chief Engineer for nine years, and more recently, as Consulting Engineer, he did more than it is often given to one man to do for a city in providing it with a good and ample water-supply and a proper system of sewerage and sewage disposal.

When he gave up the position of Chief Engineer of the Rochester Water-Works and moved to New York, one of the daily papers said of him:

> In every capacity his daily course has had four characteristics—absolute integrity, tireless industry, zeal for the public good, professional honor. He had the rare quality of command of detail combined with a broad conception of general principles and far-reaching results.

This unusual tribute to a retiring city official was as unusual as it was gratifying.

He had an inquiring mind. He was always looking for an explanation of the unexpected happenings in his daily life and work, and in his search for answers he had a remarkable faculty of knowing where to look and of scrutinizing the work and experience of others, and of making it contribute to the explanation.

His ample library was useful to him to an extent rarely reached by engineers. He never spared the midnight oil and seldom forgot, and his mind was loaded with orderly and available memories of the experiences and trials, successes and failures in the line of his chosen work. No one could think of so many reasons why a proposed structure would be weak or would fail in its intended work, or could cite the precedents for it, successful and otherwise, more surely and accurately.

His views as to the merits and defects of works and designs that he examined were bluntly conveyed when occasion demanded, in language so clear that the exact meaning could never be for a moment in doubt. This often led to the feeling that he was severe and too pessimistic about new ventures, but to those who knew him well, and could face the force and vigor of his criticism, he was helpful to an extent that it is hard to indicate adequately.

He was a man who thought vigorously and well, and who made others think for themselves even when they did not wish to think. By his own work in design, by his criticism of the work of others, and by his influence upon the many engineers with whom he came in contact, he contributed directly and indirectly to the sound, safe and durable design of American water-works structures, and his influence will extend far beyond the works with which he was directly connected.

It is interesting to inquire how such men are trained and produced. The answer must often be unsatisfactory because the influences that were strongest in the boy and the young man are not the ones that are best known to those who come after; but in Mr. Kuichling's case may be noted the practical experience of a thirteen-year-old boy with a master builder, the busy summer vacations of the school life always devoted to engineering work, the ample and broad education, first, at Rochester University, and afterward, beginning at the age of 22, at the Technical School at Karlsruhe, Germany, followed by the twelve-year-long drill as Assistant to a strong and able chief, the late J. N. Tubbs, in which there were ample opportunities for study of the qualities of men as citizens, as politicians, as contractors, as chiefs, and as assistants, as well as of the simpler qualities of the masonry, metal and water that were the more direct objects of his work. Experiences during this time led to the drafting of new specifications and contracts to meet local troubles. These were models of expression, always being definite and clear. No paragraphs from specifications have been copied and used more widely than these.

E. Kuichling

Mr. Kuichling was born at Kehl, Germany, in 1848, came to Rochester as an infant with his father, Dr. Louis Kuichling, and spent the greater part of his life there. He graduated at Rochester University in 1868, and at the Technical School at Karlsruhe, in 1872. He was connected with the Rochester Water-Works as Assistant Engineer for twelve years, from 1873 to 1885, as a member of the Executive Board from 1885 to 1887, as Chief Engineer from 1890 to 1899, and more recently as Consulting Engineer. He also played a most important part in developing and designing the sewerage and sewage-disposal systems of that city.

For many years, while at Rochester, he acted as engineering adviser of the New York State Department of Health. He acted at one time as hydraulic engineer for

*Consulting Civil Engineer, 30 East 42nd St., New York City.

the barge canal, and also conducted, while still at Rochester, a growing advisory practice in water-works and hydraulic matters. Since Jan. 1, 1900, he had lived in New York City, and had continued this practice actively, and in it had aided in the development of water-supplies and water powers all over the country.

With simple tastes and habits, Mr. Kuichling early learned from his parents the rare art of graceful and delightful entertaining, and he was indeed fortunate who experienced the full measure of his hospitality.

He was a member, and had been a Director and Vice-President, of the American Society of Civil Engineers, and had been President of the Rochester Engineering Society. He was also a member of the American and the New England Water-Works Associations, of the American Public Health Association, the Engineers' Club, and of the Masonic Orders.

Among Mr. Kuichling's numerous technical writings a few technical society papers and professional reports may be mentioned:

American Society of Civil Engineers—(1) The Relation between the Rainfall and Discharge of Sewers in Populous Districts. 1889. (2) Loss of Head Resulting from the Passage of Water through a 24-Inch Stop Valve. 1892. (3) The Financial Management of Water-Works. 1897.

New England Water-Works Association—Steel Pipes for Water-Works. 1910.

Professional Reports—(1) Report on the Water Supply of the Proposed Enlarged Erie Canal, 1901. (2) Report on the Disposal of the Sewage of the City of Rochester, 1907.

Mr. Kuichling married Sarah Louise Caldwell in 1879, and she survives him.

Resolutions on the Death of Emil Kuichling

The following resolutions on the death of Emil Kuichling were adopted by the Rochester Engineering Society, of Rochester, N. Y., on Nov. 13, 1914:

Whereas, Emil Kuichling, one of the founders of this Society and its first Chairman, was suddenly taken from us, Nov. 9, 1914, while still in the active practice of his profession; therefore, be it

Resolved, That we, the members of the Rochester Engineering Society, hereby express our appreciation of his notable qualities, which were known to most of us by reputation and to many of us by long personal contact with the man and with his work.

He was a master of detail, a profound student, a tireless investigator and an indefatigable worker; and this mode of thought led him to record, with the greatest care, the results of his investigations, observations and studies.

His reasoning was keen, and his presentation of a case was made clear by a wealth of illustration which appealed to his hearers. He delighted to sift evidence and winnow the wheat from the chaff.

He was always busy, and yet always ready and willing to give of his time and wisdom to younger men who were seeking for truth. Many young engineers who were personally associated with him found him a hard master, but in later years they invariably recognized the value and the spirit of their training.

His thoroughness exhausted the possibilities before settling upon a mode of procedure. He was critical in the extreme, both of his own work and that of others, and uncompromising where loose methods or lack of study was evidenced.

He was exceptionally well versed in the literature of his profession in several languages, and was keenly interested in new developments, while keeping well within the best conservative practice.

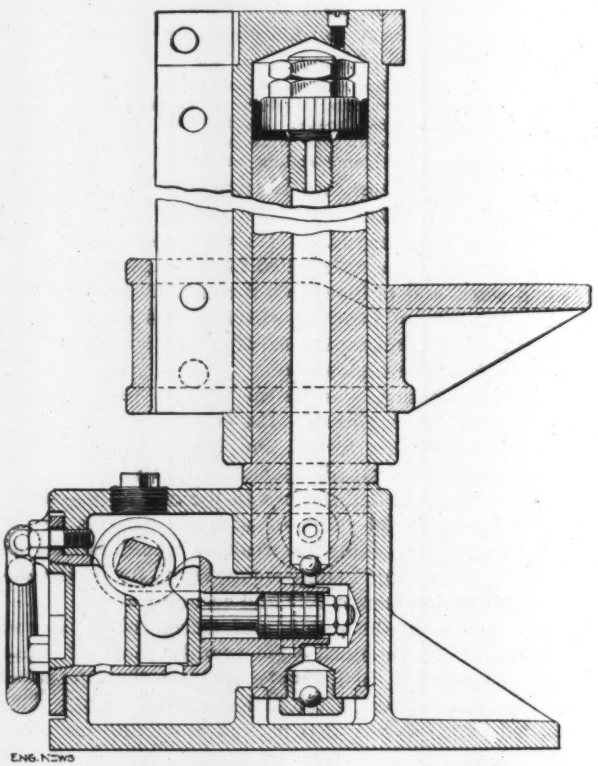
Resolved, That the profession has lost one of its leading lights; the body politic, one of its best citizens; and this Society, one of its most honored members.

Resolved, That we extend to Mrs. Kuichling our warmest sympathy, and that a copy of these resolutions be spread upon our minutes.

A Hydraulic Jack for Emergency Service

The unique design of hydraulic jack shown in the accompanying figure was first evolved for electric-railway emergency service (according to the requirements of the Pennsylvania Public Service Commisssion), but has certain obvious advantages for shop and field use.

The pump (horizontal) and plunger (vertical) are fixed to the base and the cylinder rises, carrying with it an adjustable claw which can be swung through 360° without shifting the jack and which can be set at the most convenient initial height. This arrangement allows the pump handle to be worked from the most accessible position in each case. The handle is curved and the socket has four holes so that the pump can be worked from either above or below or from either front or back.



THE WATSON-STILLMAN EMERGENCY JACK

The pump plunger is packed with leather rings between compression plates; the ram plunger has a single cup packing. The valves are simple balls and the oil under pressure flows up through the ram piston and packing bolt. For release, a needle valve on the side opens a passage from the hollow piston to the reservoir in the base. An "ice-machine" mineral oil is used, as this has been found to cause no appreciable deterioration of the packing and does not congeal at the temperatures met with in emergency service.

The jack described is made by the Watson-Stillman Co., of New York. Two sizes, five- and ten-ton, are being put out at present. With each size a 125-lb. man can secure the maximum lift for which the ram is intended. The stroke is 10 in. in both sizes and the parts are proportioned for 50% overload.

NEWS NOTES

Explosions Wrecked Dye Works—The plant of the W. Beckers Aniline & Chemical Works, Brooklyn, N. Y., was destroyed by two heavy explosions resulting from experimentation. A young chemist was killed and 50 other men were injured. The damage was estimated at about $100,000.

The Houston Ship Channel, which provides a 25-ft. depth from the Gulf to Houston, Tex., was formally opened on Nov. 10, by President Wilson pressing a button in Washington, which fired a signal in Houston. The channel was described in "Engineering News," July 13, 1914, p. 188. Wharves, docks and other port appurtenances have not been completed, but a bond issue of $3,000,000 has been approved for that purpose.

Bids for Repair of Moodna Siphon, Catskill Aqueduct—The bids for driving a shaft about 400 ft. deep and a section of tunnel 900 ft. long, to supplement the existing Catskill Aqueduct at Storm King, have been received. The five lowest are as follows: Oscar Daniels Co., $365,926; T. A. Gillespie Co., $382,290; Mason & Hanger Co., $387,499; Pittsburgh Contracting Co., $389,207; J. F. Cogan Co., $394,816. This work was discussed in our issue of Nov. 5, p. 954.

The Club House of the Cleveland Yacht Club is being moved seven miles by means of three scows. It is a 2½-story frame structure, 50x70 ft. in plan. The contractor is G. Alexander & Sons, Movers, and it is understood that the water transportation will be effected by the American Construction Co.

An Ambitious Dock Scheme on Lake Erie at Cleveland, Ohio, has been proposed by O. C. Barber, the Cleveland match manufacturer. The plan contemplates extensive ore, coal and merchandise docks on the lake front between East 55th St. and East 67th St., and a four-track subway connecting the dock and warehouses with the Cuyahoga Valley some miles south, where there would be about eight miles of track frontage for manufacturing sites. The scheme is estimated to cost about $9,000,000. Just at present there seems to be no immediate prospect of its being carried out, and furthermore, it is in violation in some respects of the federal government's scheme for developing the lake front at Cleveland.

The New Refuse Incineration Plant for San Francisco, described in our issue of Jan. 15, 1914, was recently subjected to a 30-day test under the direction of M. M. O'Shaughnessy, City Engineer. On Nov. 14, Mr. O'Shaughnessy reported that the incineration was imperfect, the smoke excessive and that other defects existed. He also reported that the cost of incineration during the test was $1.33 per ton, which is about 20% above the guarantee. He recommended that the city reject the plant and enter suit for the return of the money already paid to the contractor, the Destructor Co., of New York City. This recommendation will come up for action by the Board of Supervisors of San Francisco on Nov. 23.

A Diversion of the Little Calumet River, south of Chicago, is proposed in connection with a land drainage and reclamation project known as the Burns Ditch project. The river now discharges into Lake Michigan at South Chicago, but the diversion channel will discharge at Tolleston, Ind., and will take the water from about 50% of the drainage area of the river, thus reducing the floods which now occur along the river in Illinois. It is considered that this will benefit the drainage problem of the Sanitary District of Chicago, which is now building the Sag Canal from the Calumet region to the main drainage canal. The new ditch would take the water coming from the rural districts, and thus tend to decrease the amount of pollution that is scoured up and discharged into the lake at South Chicago by every moderate flood. The Burns Ditch project is now in the courts, as it is to be paid for by special assessment.

Channel Clearing on the Kaw River—The Board of Directors of the Kaw Valley Drainage District, Wyandotte County, Kansas City, Kan., is contemplating the cleaning out of the Kaw River channel from its mouth to a point at least six miles above same. This work embraces the removal of all solid obstructions such as piling, jetties, rock, box-cars, car tracks, etc., and the removal of dirt lying between levees to a depth of at least 30 ft. below the tops of same. This amounts to approximately one million yards. The Board of Erection contemplates the removal of the dirt by means of a hydraulic dredge discharging on top of and behind the levees at points determined by the Board. The United States Government has reported on the removal of the solid obstructions. The report states that wherever said obstructions might be identified as belonging to any of the railroads, the stock yards company or the various packing companies, the cost of the removal should be charged to said company; the cost of the removal of the unidentified obstructions to be borne equally by the Drainage Board and the Government.

The Largest Automatic Sewage Pumping Station in the World, with a total capacity of 151,000,000 gal. per 24 hr., is now being built by the Public Works Department of Boston at Union Park and Albany St. The sewage will reach the station through a 7 ft. 4 in. by 4 ft. 10 in. sewer, passing through a 15x29-ft. screen chamber to the pump suction well and will be raised about 13½ ft. into a 5 ft. 9 in. by 5 ft. 3 in. force main. Four pumps will be installed, three having 36-in. suctions and 36-in. discharges to deliver 30,000 gal. per min. each, and one having a 26-in. suction and 24-in. discharge to deliver 15,000 gal. per min. The larger pumps will be driven by 150-hp. constant-speed motors, operating on a 440-volt circuit and the smaller pump will be driven by a similar 75-hp. motor. Each pump will be equipped with an air-relief valve, pressure gage, recording tachometer and a 2½-in. gate valve with hose coupling nozzle for flushing. The automatic control is obtained by a float, moving in a 24-in. control-float well, which will actuate a multipoint switch on an independent switchboard. This switch will close five circuits consecutively as the elevation of the sewage in the suction chamber changes. The first circuit energizes the operating winding of the magnetic switch which connects the transformers across the line. The other four circuits control the pumps. The superstructure of the pumping station will be 40x65 ft. and will contain an office, shop, transformer room and motor room.

PERSONALS

Mr. Dorsey J. Parker, of Alabama, has been appointed mining engineer in the Bureau of Mines, Pittsburgh, Penn., and his appointment has been approved by the Secretary of the Interior.

Mr. William T. Sitt, Assoc. M. Am. Soc. C. E., who was connected with Wells Bros Co., of New York City, for the past 12 years, retired from the active service of the company on Oct. 1, and has taken up private practice, specializing in the design and construction of foundations and buildings.

Mr. M. Z. Richards, Land and Industrial Agent of the Southern Ry., has been appointed Commissioner of the Industrial and Agricultural Department recently formed by consolidation of land, industrial, farm improvement and livestock departments. Mr. Richards has been in railway service since 1881.

Mr. Robert Sayre Kent is President of Robert Sayre Kent, Inc., Engineers, recently formed. The new concern will continue Mr. Kent's former business—designing, superintending and operating sugar factories and refineries, iron foundries, etc.—and will have offices at the old address (50 Court St., Brooklyn, N. Y.).

Messrs. Frank A. Randall, Assoc. M. Am. Soc. C. E., since 1912 Chief Engineer of Morey, Newgard & Co., Chicago, and William H. Warner, structural designer with Graham, Burnham & Co., Chicago, have opened an office for the practice of civil and structural engineering in Chicago, under the firm name of Randall & Warner.

OBITUARY

Orlen W. Sealand, Superintendent of the Sun Oil Co., of Toledo, Ohio, was overcome by carbon-monoxide gas at the plant, on Nov. 11, and died from the effects on the same day. Mr. Sealand was graduated from the Case School of Applied Science in 1904.

Louis M. Clement, M. Inst. C. E., a well known West Coast civil and mechanical engineer, died Oct. 29, at his home, Hayward, Calif. He was an engineer on construction work for the Central Pacific R.R. in 1861. Later he designed and built the Hayes St. cable railway in San Francisco and other street railways in that city and Oakland. He was for many years Consulting Engineer of the Southern Pacific Co. He was born in Canada in 1837 and went overland to California in the days before transcontinental railways. He was a former member of the American Society of Civil Engineers, the American Society of Mechanical Engineers and the Canadian Society of Civil Engineers.

Daniel A. Camfield, a contractor of Greeley, Colo., died in New York City, on Nov. 10, as the result of a stroke of ap-

oplexy. [redacted]as about 50 years old and for 20 years had been in [redacted]ting business in the West, where he handled a num[redacted] large irrigation contracts. He was the owner of a newspaper in Greeley, and was interested in the Greeley Water Co.

Edward C. Burns, M. Am. Soc. C. E., a prominent civil engineer of Jamestown. N. Y., died there, Oct. 29, after an illness of more than a year. He was born in New York City in 1845. In his youth he attended the Patterson Preparatory School, Detroit, Mich., where he prepared for the civil engineering course at the University of Michigan, graduating from the latter institution in 1868. After graduation he engaged in railway construction in Iowa and Illinois in positions ranging from rodman to chief engineer, until 1871 when he assumed charge of the construction of the Pittsburgh, Bessemer & Lake Erie R.R., as Chief Engineer. In 1872 he supervised the construction of the Buffalo & Southwestern R.R. from Gowanda to Jamestown. From 1877 to 1885 he was United States Assistant Engineer on river and harbor work, and was engaged in the construction of the Sault Ste. Marie canal, the repair of the St. Claire canal, and the dredging of the Livingston channel in the Detroit River. Since 1885 Burns resided at Jamestown, serving for several years on the Board of Public Works, and has many times been engaged as consulting engineer for the city. He was one of the commissioners for the drainage of the Cinewango swamp and was the engineer of this important work. For thirty-five years E. C. Burns was an active member of the American Society of Civil Engineers.

ENGINEERING SOCIETIES

COMING MEETINGS

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Nov. 30-Dec. 1. Annual meeting at New York. Secy., W. H. Ross, 154 Nassau St., New York City.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Nov. 30-Dec. 5. Annual meeting at Jacksonville, Fla. Secy., Prof. Selskar M. Gunn, Massachusetts Institute of Technology, Boston, Mass.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 1-4. Annual meeting at New York City. Secy., Calvin W. Rice, 29 W. 39th St., New York City.

AMERICAN INSTITUTE OF ARCHITECTS.
Dec. 2-4. Convention at Washington, D. C. Secy., D. Knickabacker Boyd, The Octagon, Washington, D. C.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 7-10. Annual meeting in New York City. Secy., Percy H. Wilson, Bellevue Court Bldg., Philadelphia, Penn.

AMERICAN MINING CONGRESS.
Dec. 7-11. Annual meeting at Phœnix, Ariz. Secy., J. F. Callbreath, Denver, Colo.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Dec. 9-12. Convention at Richmond, Va. Secy., C. A Prosser, 140 W. 42d St., New York City.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Dec. 10-11. Annual meeting at New York City. Secy., D. H. Cox, 29 W. 39th St., New York City.

AMERICAN ROAD BUILDERS' ASSOCIATION.
Dec. 14-18. Convention at Chicago, Ill. Secy., E. L. Powers, 150 Nassau St., New York City.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 28-30. Annual meeting at Chicago, Ill. Secy., F. M. White, Madison, Wis.

National Society for the Promotion of Industrial Education—The eighth annual convention of the Society will be held in Richmond, Va., Dec. 9-12, with headquarters at the Hotel Jefferson. The National Vocational Guidance Association will hold its annual meeting in the same city, Dec. 7-9. The advance program of the Society has been prepared and can be obtained from the Secretary, C. A. Prosser, 140 West 42d St., New York City.

Society of Naval Architects and Marine Engineers—The 22d general meeting of the Society will be held in the Engineering Societies Building, New York City, Dec. 10-11, sessions beginning at 10 a.m. each day. The annual banquet will be held in the Astor Gallery of the Waldorf-Astoria at 7 p.m., Dec. 11. The final list of papers includes the following: "Safety of Life from Fire at Sea," W. O. Teague; "Launching Data for a Battleship," Naval Constructor J. G. Tawresey; "Stability of Vessels as Affected by Damage Due to Collision," William Gatewood; "Expansion or Contraction of Certain Dimensions and the Effect upon Resistance," Prof. H. C. Sadler; "Recent Developments in Submarine Signaling," J. B. Millet; "The Thermodynamics of the Marine Oil Engine," John F. Wentworth; "Refueling of Warships at Sea," Spencer Miller; "The Behavior of Riveted Joints under Stresses," James E. Howard; "The Present Status of Marine Diesel Engine Installations," W. R. Haynie; "The Application of Electric Propulsion to Battleships, together with the Experience Gained in the 'Jupiter,'" Lieut. S. M. Robinson.

New England Water Works Association—At the first monthly meeting of the 1914-15 season, held in Boston, Mass., Nov. 11, two interesting and instructive papers were presented on the two newest methods of sterilizing water-supplies. Dr. Max von Recklinghausen described the sterilization of water with ultra-violet rays, beginning with an outline of the principles involved, including many results of the author's experiments and experience with French installations, and ending with a statement that several large installations were under consideration in this country. The paper was very optimistic in its conclusions on the efficiency of this method of water purification. Sheppard T. Powell's paper on the use of ozone as a sterilizing agent was read, but in the absence of the author was not discussed. This paper gave an interesting and valuable summary of American experience in the use of ozone, discussing particularly the difficulties and the causes of failure in many instances. The paper gave in some detail the changes which have been made in the Ann Arbor, Mich., plant and the results of experiments there and elsewhere, both in removal of bacteria and of color and odors, together with cost data. Mr. Powell's conclusions were, that ozone was an efficient means of removing all three of these objectionable features in water, but he recognized at the same time that it was not a cure-all; that former failures with ozone as a disinfecting agent were due to want of perfection in mechanical details and operating methods. On the whole, this paper was very optimistic on use of ozone as a water-sterilizing agent. The topical discussion on the general subject of service pipes was long and interesting and many water-works officials of long experience took part. This discussion covered little more than the kind of pipe to use; other branches of the subject will probably be taken up at other meetings. Lead pipe seemed to be the prime favorite, and it was stated that objections to it were in many instances æsthetic rather than founded on any real danger in its use. Cement-lined iron pipe was next in popularity and several instances were given of very satisfactory results with galvanized-iron pipe.

Conference of American Mayors on Public Policies as to Municipal Utilities—A large gathering of mayors and others interested in the regulation of public utilities was held in Philadelphia on Nov. 13 and 14, 1914. The conference was called by the following mayors: Rudolph Blankenburg, Philadelphia; John P. Mitchel, New York; Carter H. Harrison, Chicago; Newton D. Baker, Cleveland; Geo. W. Shroyer, Dayton. At the two evening sessions, the mayors and delegates were the guests of the American Academy of Political and Social Science.

There were numerous addresses on state and local regulation of public utilities, municipal ownership and operation, both in theory and practice, and municipal home rule. The sentiment of the conference seemed to be almost wholly in favor of municipal ownership, qualified chiefly, if at all, by conditions of local expediency. There was also expressed much strong feeling against state and in favor of local regulation of public-service corporations, but this was tempered with considerable recognition of the fact that utility regulation is largely a matter of state concern, and, except for the larger cities, too big a problem for single communities. Strenuous objections were voiced against state regulation of municipally-owned public utilities, but this view was not accepted by all the speakers.

At the end of the conference a Committee on recommendations, of which Mayor Baker, of Cleveland, was Chairman, reported as follows: (1) No stand should be taken for or against municipal ownership, but it is highly important that every municipality have a free hand in this matter. (2) No stand should be taken on state as against local regulation of privately-owned utilities, but all franchise grants should be made by the municipality alone, and municipally-owned utilities should be subject to local control, only. (3) The trustees of The Utilities Bureau should proceed with its organization, establish an office, keep records, employ experts and render service to individual cities. This report was adopted.

It may be added that The Public Utilities Bureau has as its sponsors the five mayors named above, and that among its eight trustees are Frederick A. Cleveland, Director of the New York Bureau of Municipal Research, Frederick W. Taylor, Consulting Engineer, Philadelphia, and Chas. R. Van Hise, President of the University of Wisconsin, Madison, Wis. The temporary office of the Bureau is at 216 City Hall, Philadelphia, Penn.

Engineering Literature

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CORRESPONDENCE

A Card-Index Multiplication Table

Sir—I read Mr. Rossiter R. Potter's article on "Cox's Commercial Calculator" in your issue of Oct. 15 with much interest, as I abandoned that system after doing a large amount of work on it in favor of a system which I patented in 1910.

F. C. WILLIAMS.

Commercial Bank Building,
Cleveland, Ohio, Oct. 29, 1914.

[From a pamphlet sent by Mr. Williams it appears that his "Multiplying Device" is "simply a large multiplication table," in card index form. Products up to 9×999 can be read directly. Beyond that simple multiplication followed by addition is required.—EDITOR.]

On Methods of Instruction in Surveying

Sir—I note the criticism on the expediency of teaching surveying by the use of worked-out problems, in the review of my book, in your issue of Aug. 14. You said:

Is it better to tell a young man what you want done and leave it to his initiative and ingenuity to devise the best ways and means, with the help of necessary text-books and verbal instructions, or to give him a cut-and-dried problem and say, go thou and do likewise? To help train a real engineer, we would prefer the former.

In defense of the above criticism, I wish to state that the "Field Manual of Plane Surveying and Railroad Curves" is intended to be the A B C of Plane Surveying. It is designed to help the student at a time when he not only has to learn the form of report, but also the principle of the problem. By placing a few well selected fundamental problems at his convenience, he is started in the right direction without an excessive amount of personal supervision; that is, he is able to help himself in the early stages of the work by this convenience.

After he has completed these first few problems in plane surveying, he takes up the second and third terms of surveying without any assistance except what he can get from the standard text or his instructor. He is then thrown upon his own resources to make notes to suit the problem he has in hand. We have tried this test for two terms and have found it to give the results that were expected.

If the above criticism can be applied to this text it may also be applied to a number of other texts which have been successful. The only difference between this and other manuals is the matter of convenience. The others have their field notes photographed and printed along with detailed instructions about apparatus and method of procedure.

If the field book is used, it is necessary for the student to carry both manual and field book to the field, which is inconvenient. The student is also expected to buy and read a reference work. The expense of these three books is too large when we consider the fact that he is paying for the same instruction three times. The reference book gives it to him once and the manual twice (first in the form of instructions as to apparatus and method, second in reproduced field notes). If the problem is reviewed in class, he receives the same instruction four times. The purpose of the Field Manual is to eliminate one of these repetitions, by combining the necessary part of the manual and the field book, which reduces the expenses and adds greatly to the convenience of the student. At Valparaiso University we have saved every student $1.50 on his plane surveying book bill and he has just as much for his money.

It is our policy to encourage a man's initiative and ingenuity to devise the best ways and means to do his work, and this is done in due time, but in the beginning of a subject it is necessary to teach him some form or convention in which there is no opportunity for initiative or ingenuity. Just as soon as the work advances to a stage where a variety of form is possible, we give him the opportunity of making for himself his own plan.

R. C. YEOMAN.

Valparaiso, Ind., Nov. 5, 1914.

[The author shows the reason for using the kind of field book we have criticized when he says it answers the purpose "without an excessive amount of personal supervision." In other words, he uses the book for exactly the purpose we suggested. It seems to us that any young man who has a fair knowledge of geometry and trigonometry does not need to exercise any great amount of ingenuity to work out and keep the notes of simple surveying problems, if he is given a very moderate amount of verbal instruction, with what he can glean for himself from standard textbooks. It is not a question of easing the work of the instructor, but of making a surveyor.—EDITOR.]

REVIEWS AND NOTES

A Brief Text on Foundations

REVIEWED BY C. S. RINDSFOOS*

FOUNDATIONS: A Short Text-Book on Ordinary Foundations, including a Brief Description of the Methods Used for Difficult Foundations—By Malverd A. Howe, M. Am. Soc. C. E., Professor of Civil Engineering, Rose Polytechnic Institute. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd. Cloth; 6x9 in.; pp. vii + 110; 55 text figures. $1.25, net.

It is curious to note that foundations, so long neglected, have become, all at once, a popular subject for the authors of textbooks. Within the past few months, three such books have appeared. In a previous review of one of these, the writer made the criticism that too large an amount of matter had been crowded between one set of covers, and that a division into two volumes would have produced greater convenience. In the book which is the subject of the present review, the opposite extreme prevails. The material is so abbreviated that its use will be found to be quite limited.

The author announces that "the object is to state in an elementary manner the fundamental principles upon which the proper design of foundations is based," and again that "an attempt has been made to so present and arrange the subject matter that the book can be successfully used as a textbook." With these things in mind, the fact that the work is so small is at least understandable, and yet it is hard to see wherein the book will offer any advantage over one of the more complete texts which have appeared previously, unless it be in the matter of cost to the student who will use it, or unless it has been arranged to fit a certain course in a particular college.

The book is divided into six chapters, as follows: Supporting capacity of soils; wall and column footings; piles and pile foundations; chimneys and towers; bridge piers and abutments; and methods employed for difficult foundations.

Many formulas are given for the design of different types of foundations, as well as examples under each topic, the answer in each case being stated.

With one or two exceptions, nothing is presented on any of these topics that had not already appeared in book form several years ago. The descriptions are so brief that the elementary student would not be greatly benefited unless there be amplification in the form of lectures or other reading. Many references to other books and to current periodicals are included for this purpose, and this feature deserves commendation.

In conclusion, it should be said that the book is elementary, concise and will be of some use to the student—though a monostich on so broad a subject can be of but doubtful value.

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REPORT ON EUROPEAN PAVEMENTS—By George W. Tillson, Consulting Engineer to the President, Borough of Brooklyn, New York City. Brooklyn, N. Y.: Borough Hall. Paper; 7x10 in.; pp. 98; 98 illustrated.

The author gives, in narrative form, a description of the kind and condition of the pavements of a number of European cities, as observed by him in the summer of 1913 while abroad as official delegate of the City of New York to the International Road Congress. About 100 illustrations, extracts from specifications, and cost data are also included.

Mr. Tillson concludes that the general condition of pavements in European city streets is better than that of the streets of American cities. In Europe, he says a great deal of attention is given to proper repairs, which he thinks is not true in the average American city. Another reason for the superiority of European pavements, the author thinks, is that fewer pavement openings for subsurface structures are made there than here. In Europe, the authority of highway officials generally includes jurisdiction over the construction of subsurface structures.

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Popular Books on Aeronautics

FLIGHT WITHOUT FORMULAE: Simple Discussions on the Mechanics of the Aëroplane—By Commandant Duchêne, of the French Génie; author of "The Mechanics of the Aëroplane." Translated from the French by John H. Ledeboer, Editor, "Aëronautics"; joint-author of "The Aëroplane." New York and London: Longmans, Green & Co. Cloth; 6x9 in.; pp. 211; 84 text figures. $2.25, net.

HARPER'S AIRCRAFT BOOK: Why Aëroplanes Fly, How to Make Models and All About Aircraft, Little and Big—By A. Hyatt Verrill, author "Harper's Book for Young Naturalists." New York and London: Harper & Brothers. Cloth; 5x8 in.; pp. xv + 245; illustrated. $1, net.

Commandant Duchene and his translator, Mr. Le Deboer, have attempted to execute a flank movement on those would-be deeper students of aëronautics who are deterred by the formidable mathematical expressions encountered as soon as they open the usual volume on the mechanics of flight and flying machines. This book gives no formulas, it is true, but it presents the same information by reverting to ordinary language—divided by, multiplied by, added to, minus, etc., in place of mathematical expressions—and by graphs, when the relations between variables become more complex.

Lift-resistance-speed relations are first presented and followed by power required for sustentation, etc. This last topic is treated at length and occupies some 30% of the book. Stability has a place of equal importance with some 40% of the pages, the matters of longitudinal, lateral and directional stability being discussed in separate sections. Many of the ideas are visualized by simple and interesting experiments easily performed by any reader.

What has been noted so far relates to manipulations in still air; for completeness a neat little discussion of air currents—steady winds and intermittent gusts—is appended as the final chapter.

The author and translator have succeeded in producing a brief treatise of appealing simplicity and pleasing literary style.

The "Aircraft Book" is made upon the usual lines of this sort of treatise and its value depends on detailed execution of the project rather than novelty of approach. Conspicuous among the author's efforts are the attempts to explain flight simply enough to fit the minds of boys. Of these attempts he has expressed a most optimistic confidence in his success; however, he can be forgiven such manifest prefatorial pride (perhaps injected by some editor) for the explanations throughout the book, though skimpy from the engineering point of view, are good for common use.

Early in the discussion of best wing shapes, an unfortunate exchange of diagrams makes the text claim that the short broad plane is more effective than the long narrow type universally seen. A very few minor points are

*United States Purchasing Corporation, Woolworth Bldg., New York City.

presented in peculiar prospective—thus the emphasis on inherent stability of certain cambered planes, which is separated from utter instability by a narrow margin and is of no practical utility yet—as the author casually remarks.

The book seems to naturally fall into several parts. One part explains the flight and control of aëroplanes and another describes the construction of small machines. These are of two general types—propelled and gliding. The author does not recommend that boys make propelled machines of carrying capacity but he seems to think it harmless to use gliders of sufficient size to support one small person. A third division of the book describes some of the more notable types of flying machines that have been developed.

A German Textbook on Hydraulic Turbines

REVIEWED BY H. E. LONGWELL*

VORLESUNGEN UBER WASSERKRAFTMASCHINEN—Von Dr. Phil. Dr.-Ing. R. Camerer, Dipl.-Ing. O. Professor des Maschinenbaues an der Kgl. Techn. Hochschule, München. Leipzig and Berlin: Wilhelm Engelmann. Cloth; 7x10 in.; pp. xxvii + 577; 718 text figures and 55 tables. 25 Marks.

This volume conveys the somewhat unusual, and altogether pleasing impression that the author's first consideration has been the realization of his ideal of an engineering textbook. In every detail it exhibits the perfection of finish that marks the craftsman who cannot permit himself to slight his work in ever so small a degree.

While intended primarily as a textbook for the author's classes, it is none the less a most useful reference work for engineers already established in practice, as it presents the subject from new viewpoints, introduces new methods of calculating, and furnishes in convenient collective form a mass of information regarding successful construction of modern hydraulic turbines, and water-power plants.

The work is divided into seven parts, of which the first is a brief general introduction to the subject, treating particularly of the physical, chemical and electrical properties of water. The second part, of 160 pages, deals with hydrostatics and hydrodynamics with special reference to the needs of the turbine engineer.

Part III treats of water-power machines in general, classifying them into the various types and giving the nomenclature of each type. This section also contains an interesting historical review of the gradual development of the crude apparatus of ancient days into the modern and highly efficient hydraulic turbine. Part IV deals with the general theory of turbines, as developed from the underlying energy law, with analytical and graphical treatment of the equations derived from this law.

Having covered his subject broadly, the author proceeds to a special consideration of the two types of turbine which he regards as the only healthy survivors of the family, viz.—the complete admission, centripetal-flow turbine (Francis type), and the tangential or pure-impulse wheel (Pelton type).

Part V elaborates the general theory of the turbine with special reference to the Francis type and Part VI deals with the practical design of turbines of this class. It is interesting to note that this section is not "padded" with material that pertains strictly to pure machine design; the author confines himself to machine design as influenced by the special conditions obtaining in the particular machines under consideration. The concluding part covers the theoretical and structural design of the tangential or Pelton-type turbine.

The 718 illustrations in the text are supplemented by 55 folding plates of diagrams, halftone reproductions of photographs, and constructional drawings of actual machines, all on a conveniently large scale. These plates are grouped at the end of the book, and have page-width margins at the left, so that when they are unfolded, no part of the engraved surface is covered by the leaves of the book—an obvious convenience for the reader. There is a table of the abbreviations used in the text and a very complete table of all the symbols. In addition to the table of contents and titles of the plates, there is an alphabetical index of subjects covering nine pages.

The printing and paper are in keeping with the excellent quality of the contents. The author has that easy, graceful—almost conversational—literary style that lends a charm to even the most abstruse subject. This style is not altogether unusual in German technical works of the better class, but unfortunately translators do not seem to appreciate its desirability, and in consequence, it is rarely, if ever, reproduced.

Gas Engines for Amateurs

HARPER'S GASOLINE ENGINE BOOK: How the Engine Is Made, How to Use It at Home, in Boats and Vehicles and Elsewhere, and How to Keep It in Order—By A. Hyatt Verrill, author of "Harper's Wireless Book." New York and London. Harper & Brothers. Cloth; 5x8 in.; pp. xx + 292; illustrated. $1, net.

The constant stream of popular books on gas engines and their applications would lead one to feel that there must be something serious the matter with the previous literature available for amateur readers. If all that have been published were as good as this one, there would not be great demand for new texts. This work, it is stated, is intended particularly for boys, but in spite of such limitations it is well adapted for non-technical readers of more advanced years.

The author's introduction is a very optimistic valuation of his own work, which naturally would tend to make a critical reader prejudiced. But he has lived up to his aims for the most part in a creditable manner—whatever one may think of bold claims to "excel all others of the kind" in this or that particular.

Certain superficialities are to be expected—indeed seem almost necessary. There is no excuse, however, for careless confusion between power and torque or force, or between power and energy, as is seen in discussing the size and power of engines. Right here also is the surprising information that indicated horsepower is computed from bore, stroke and speed alone—other matters being considered constant. It need hardly be stated here that indicated horsepower is computed from mean effective pressures, experimentally determined, dimensions and speed, while the author has confused it with one of the numerous ways of nominal rating. A similar surprise awaits anyone who believes that a two-stroke-cycle engine could be appreciably more powerful than a four-stroke-cycle type of equal weight, etc. With a very few such corrections, the book will be helpful to the me-

*Consulting engineer, Westinghouse Machine Co., East Pittsburgh, Penn.

chanic, farmer and automobilist, as well as to the boy of eighteen.

The book starts off by describing broad types and advantages, need for cooling provisions, benefit of oiling and care, etc. Then a little different tack is made to show how the engine generates its power. Single- and multi-cylinder construction is described and special designs like sleeve-valve, rotary-valve and rotating-cylinder or "star" engines. Machines for special work, as for water and air craft and for stationary plants, are well distinguished. One chapter notes prevalent general construction features of motor cars, motorcycles, cycle cars, etc. Closing sections discuss inspection and repair and troubles to be expected. An appendix shows symptoms of troubles and remedies which should be close at hand.

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Ground-Water Supplies

REVIEWED BY EMIL KUICHLING*

DAS GRUNDWASSER, SEINE ERSCHEINUNGSFORMEN, BEWEGUNGSGESETZE UND MENGENBESTIMMUNG—Von Dr.-Ing. O. Smreker. Leipzig and Berlin: Wilhelm Engelmann. Paper; 8x11 in.; pp. 67; 27 text figures. 3.20 Marks.

This monograph was written by a well known hydraulic engineer who has given special attention for many years to the development of ground-water supplies for German cities, and it was recently accepted by the Polytechnic School of Zurich as a thesis for the degree of Doctor of Technical Sciences. It points out the numerous difficulties that have prevailed in placing the subject on a sound basis, and indicates how they can be overcome in large measure, so as to make subterranean hydrology an approximately exact science.

The text is divided into seven sections or chapters, which embrace a review of the principal theories of the formation of ground-water, the interchange of surface and subsoil waters, the law of resistance to the motion of water through the ground, the efficiency of different methods of obtaining a water-supply, such as by means of vertical wells, horizontal filter galleries, and artesian wells, the determination of the shape of the cone of depression of the ground-water surface by means of experiments with pumps, and lastly, the determination of the discharge of a stream of ground-water through a given basin or cross-section.

Wherever possible the subjects are treated mathematically, and formulas are developed for the curve of depression in terms of the pumpage, the thickness of the water-bearing stratum, and certain empirical constants, which are evaluated in a very ingenious manner. The monograph thus becomes a valuable addition to the literature of ground-waters and the methods of ascertaining the probable yield for the supply of a community.

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HEAT ENGINES; Steam, Gas, Steam Turbines and Their Auxiliaries—By John R. Allen, Professor of Mechanical Engineering, and Joseph A. Bursley, Junior Professor of Mechanical Engineering; University of Michigan. Second edition, thoroughly revised and entirely reset. New York and London: McGraw-Hill Book Co., Inc. Cloth; 6x9 in.; pp. xiii + 320; 185 illustrations. $3, net.

In reviewing the first edition of this work (ENGINEERING NEWS, Oct. 13, 1910), attention was drawn to a few apparent crudities that remained—due to a rather hasty transition of the text from the lecture-note to printed-volume stage. Some little defects have been evidently remedied in the general revision needed to keep up with the engineering advance in development and design of heat engines. Yet other hasty statements that were criticized in the earlier edition persist. There has been a general improvement and modernizing of details. The new topics cover the Stumpf "Unaflow" engine and the Humphrey direct-acting explosion pump. There are additions to the treatment of steam turbines and gas engines.

To those not familiar with the first edition, the title of the book may not convey a proper idea of its scope—which embraces elementary thermodynamics, properties of steam, calorimeters, fuels, boilers, boiler auxiliaries, steam engines, engine details and testing, turbines and explosion engines.

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THE AUTOCAR IMPERIAL YEAR BOOK, 1914—London (20 Tudor St.): Iliffe & Sons, Ltd. Cardboard; 8x12 in.; pp. 126; illustrated. 2½ shillings, net.

This publication, issued by one of the principal British automobile journals, puts into permanent form, available for reference, some of the important developments of the year in British automobile engineering. The amazing development of the automobile industry in this country is matched by a similar development abroad and it is of interest to note to what a limited extent the practice of one country is reproduced in the other. The number of different makes of automobiles in England appears to be almost as great as in the United States, and the same thing is true of the enormous business in automobile parts. In the carburetor field, for example, there are 25 or 30 popular makes of carburetors in use in Great Britain which are entirely different from the equal or greater number of makes of carburetors in common use in the United States. The engineer interested in any phase of automobile development will find a great deal of valuable matter in this book. The titles of a few of the chapters will indicate its scope: The Modern Chassis, Tendencies of Design, Electric Car-Lighting Systems, Electric Engine Starters, The Progress of the Light Car, Lubricating Systems, Springing Systems, The Principal Makes of Carburetors, Royal Automobile Club's Trials of Motor Accessories and Tires, The Fuel Question, World's Records.

About the only criticism to be made of the book is that it follows the custom common in English technical and trade publications of interspersing advertising pages among the reading matter.

Automobile engineering is perhaps the youngest important branch of the engineering profession; but any civil engineer or mechanical engineer who looks upon the automobile field as a purely manufacturing field which has not yet made use of the engineer's ability to apply science to industry, will learn something if he studies such a book as the one before us.

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PRACTICAL CALCULATIONS FOR ENGINEERS, For the Use of Engineering Students, Apprentices, Mechanics, Foremen, Draftsmen, and Others Practically Engaged in Engineering Work—By C. E. Larard, M. Inst. C. E., M. I. Mech. E., Head of the Mechanical Engineering Department at the Northampton Institute, London, and H. A. Golding, Assoc. M. I. Mech. E. Third edition, revised. London: Charles Griffin & Co., Ltd. Philadelphia: J. B. Lippincott Co. Cloth; 5x8 in.; pp. xii + 387; 175 illustrations. $2, net.

The first addition of this book appeared in 1907, and was favorably noticed in our issue of March 12th, 1908 (p. 298). An enlarged and corrected edition appeared in 1909 but has been out of print for some time. In the present edition the authors state that they have made

*An obituary notice of Mr. Kuichling appears elsewhere in this issue.

"certain additions and a complete revision of the subject-matter;" also that they have omitted the major part of Section IV., which is to be published "as a separate volume in order to give a fuller treatment of the more purely commercial or business side of engineering." In noticing the first edition we characterized the book as designed "solely to give practice in making calculations, to help in the difficult task of converting school-taught principles into working tools."

Practical Rate Making and Valuation

PRACTICAL RATE MAKING AND APPRAISEMENT—By William D. Marks, author of the "Finances of Gas and Electric Light and Power Enterprises, 1900," and of Other Technical Papers and Works. South Hadley, Mass.: Office, Presidents House. Cloth; 5x8 in.; pp. 269. $2, postpaid.

Any posthumous volume of an engineer with a long and interesting career is bound to be of unique interest to many; in addition, the present volume has special interest as disclosing the inner workings of the mind of one who was among the oldest public-utility experts of the country.

It will be readily admitted that many of the methods used by the author had to be original, in the absence of precedents for the work which pioneer appraisers and rate-makers have done, but it must be regarded as unfortunate that he had such ties to the children of his own mind that he could not accept any and all improvements on them by some of the more recent entrants to the field. The ideas recorded here were good so far as they went, but they were after all not the only contributions in a field in which a multitude of equally earnest and sincere workers have gradually improved both theory and practice. The author's reluctance to see much good in some of these efforts is reflected in his severe and largely unmerited arraignment of the public-service commissions of various states. The explanation perhaps is found in some ungentle and ungenerous treatment by busy and thoughtless men. The ideas of a few were commended, and we suspect that the originators possessed more gentleness, deference and tact than some of their less fortunate fellows.

The first chapter contains a few very general and miscellaneous remarks on rate problems. These seem to show that the author viewed with suspicion the operation of all utility concerns in cities of over 25,000 population —on account of "growing into vendors of a commodity on a large scale" instead of "rendering service as a public servant." Here are first mentioned, the author's "proportional" or "commodity" and "time" costs which make up his total cost of utility service or product. The author's "proportional cost" includes chiefly productive labor and raw materials; his "time cost" covers interest, profit, depreciation, rent, insurance, general staff employees, etc. The author was on the right track when, years ago, he attempted in this way to adjust rates equitably between the short-time peak-load consumer and the customer who used a smaller amount for long hours. But his scheme will seem to many to be but one step toward the most equitable procedure possible, for on careful analysis "time" and "product" are not the fundamental tests. These are rather (1) the cost of readiness to serve, and (2) the cost of actual service—the former sometimes becoming indistinct, and the latter sometimes splitting naturally into a commodity and a customer charge.

Following are two long chapters summarizing reports made by the author for Spokane (gas) and Minneapolis (arc lighting). They are interesting as showing a *modus operandi*. In the gas case it might seem that the author's "time-cost" allocation, for a utility which stores a commodity, gives a rather high charge to be distributed according to demand whereas we now realize, using the readiness-to-serve test, that comparatively small investment (on storage facilities) and overhead organization charges can be properly apportioned according to peak demand, and that it is sometimes perhaps a distortion to have as much difference in unit prices as $1.40 and $1.04 for the small and the large customer or the ones of long hour and short in this particular type of utility. In the Minneapolis case, where water power is involved, these segregations do not become of such import as fixed charges and capacity reserve naturally control anyway.

In another chapter are discussed "quantity rates for electricity" in which appear again the ideas noted above. Each customer is advocated charged with a unit price which apportions "time" costs according to his probable maximum demand (total kilowatt-hours divided by connected load), and places the operating expenses according to metered quantity, disregarding diversity factors, and off-peak customers who have been won only by keeping them free from fixed charges on investment.

A considerable part of this chapter is given up to a severe arraignment of the electricity-rate system in New York City (based on steps of 10 to 5c. per kw.-hr., etc., without minimum charges) which scheme the author contends bears too heavily on the small consumers and extorts generally some $2,000,000 over a fair profit of 8%. This criticism is made in spite of the acquiescence of the Public Service Commission and is cited as a charge of incompetence and political complexion against this body.

The next chapter is called "Methods of Appraisement" and consists almost entirely of a reprint of the Act of Congress, approved Mar. 1, 1913, providing for the appraisal of railroads, there being appended only the author's claim that American roads are overcapitalized by seven billion dollars out of 12½ billion—a view not generally shared by engineers. In the following four chapters valuation discussions are continued—by suggestions for organizing an inventory-unit price attack; by use of 12½ to 15% for overhead expenses; formulation of depreciation allowances; fixing real-estate values; comparative appraisals; market value, franchise value, development expense, going values, and other intangible elements.

The remainder of the volume may be considered miscellany, more or less connected to the preceding. Under "accounts" is a brief reference to reclassifying a concern's expense reports according to the author's "time" and "commodity" segregation. Under "law of demand for electricity" is a study of rates in Massachusetts cities which shows that sales per capita seemed to depend upon an empirical hyperbolic law [sales = (640 ÷ price) — 45]. The gas sales studied exhibit greater complexity and show no such simple relation. There is a brief review of the London "sliding scale" for gas companies, by which corporation dividends are increased with price reduction, and an outline of a similar dividing scale of the author's devising by which the decrease in rates equals the increased corporation return or other factors.

Compressed-Air Pumping

REVIEWED BY C. R. WEIDNER*

PUMPING BY COMPRESSED AIR—By Edmund M. Ivens. Jun. M. Am. Soc. M. E. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd. Cloth; 6x9 in.; pp. vi + 244; 106 text figures. $3.

Mr. Ivens' book on Pumping by Compressed Air is, so far as the reviewer knows, the first written in the English language, which deals exclusively with that subject. An excellent German work has appeared recently, however, and the subject has also been dealt with briefly in various works on Compressed Air.

The author has compiled, in convenient and condensed form, the essential information on compressed-air pumping which has been published in technical-society journals, engineering periodicals and manufacturers' catalogs; with this he has combined matter derived from his personal practice, including tests on operating plants.

The first chapter takes up very briefly the direct-acting plunger pump operated by compressed air. The second and third chapters describe various types of displacement pumps, in which the air displaces the liquid in one or more chambers, and is then either exhausted into the atmosphere or piped back to the compressor. The results of tests on both methods and a theoretical analysis of the return-air system are given. The reviewer would criticize the allotment of space given to the over-detailed description of one of these tests, since the installation described is one rarely met with in practice. Thirty-two out of a total of 232 pages of text are used for this purpose, which are quoted from a readily accessible source.

The major portion of the book, chapters 4 to 8, inclusive, is devoted to the history, theory, design, tests and descriptions of the air lift. Engineers will be especially interested in this part, as the air lift offers the most advantageous field for compressed-air pumping and little of definite value has been published in English, relating to the design of this system. Although a proper design is largely a matter of experiment, the fundamental principles are clearly stated, and formulas, diagrams and tables are given, which are extremely useful. As an illustration, a set of conditions is assumed and the design worked out in detail.

Although the material in the five remaining chapters can be found in books on thermodynamics, compressed air, and hydraulics, it is, however, convenient to have it presented here. Chapter 9 relates to compression generalities, Chapter 10 to the air card and to air-compressor efficiency, and practical hints on the installation and operation of the compressor are given in Chapter 11. Numerous typographical errors, or errors due to insufficient proofreading, mar Chapters 12 and 13, dealing, respectively, with the flow of air and water in pipes. The formula given in the last chapter for loss of head due to expansion or contraction of section is clearly in error.

The demand for a book of this kind has been made evident to the reviewer by the large number of requests from water-supply engineers and superintendents, chemists and manufacturers, for a bulletin on the air lift, which was published several years ago by the University of Wisconsin; and, notwithstanding the minor defects pointed out, he feels assured that Mr. Iven's book will meet their needs. For classes in hydraulic machinery and compressed-air practice, it should be of value for reference, both to the teacher and student.

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ACOUSTICS OF AUDITORIUMS—By F. R. Watson, Urbana, Ill.; Engineering Experiment Station, University of Illinois, Bulletin 73. Paper; 6x9 in.; pp. 32; illustrated. 25c.

It would be difficult to find a technical subject of direct interest to the engineering and architectural professions, on which such general ignorance exists, and which is at the same time so important, as the subject to which this pamphlet is devoted. Apparently, most engineers, and architects as well, appear to think that the acoustic properties of a public hall or other auditorium are purely a matter of luck. Knowledge of the investigations that have been made within the last 15 years to determine the laws which govern the acoustic properties of auditoriums, is not yet widely disseminated. This bulletin by Professor Watson summarizes the principal elements which determine the acoustic properties of an auditorium, and describes the various experiments and investigations which were made at the University of Illinois, especially in connection with the auditorium at the University, which was seriously defective in its acoustic properties.

It is a good illustration of the popular ignorance of acoustics, among those who should be best informed, that many of the buildings at our universities are notably bad in acoustic properties. Another illustration is the hall in the house of the American Society of Civil Engineers, in New York City, which is so bad acoustically that a large part of the proceedings of any general meeting there are lost to the audience.

One of the main elements in determining the acoustic properties of an auditorium is the extent to which its wall surfaces reflect sound. There is good reason to believe that the acoustics of the average church or auditorium are a good deal worse today than they were in the simpler structures in use twenty years or more ago, and that the reason for this is the general substitution, which has taken place during that time, of hard patent plasters as a wall covering in place of the more or less porous lime mortar formerly used. A bibliography of publications on the acoustics of auditoriums concludes the bulletin.

REPORT ON THE BUILDING AND ORNAMENTAL STONES OF CANADA—Vol. II, Maritime Provinces. By Wm. A. Parks. Ottawa: Mines Branch, Department of Mines. Paper; 7x10 in.; pp. 264; illustrated.

Engineers, contractors and architects will find this a valuable reference book for building work in the Canadian Maritime Provinces. The fieldwork upon which the report is based included not only about 60 quarries, but many abandoned quarries and prospects. It is believed by the authors that every stone commercially available at the present time in this region has received due consideration. The descriptions of building stone include not only its physical and chemical characteristics, but the facilities and equipment of the various quarries for producing commercial blocks.

A STUDY OF RAPID TRANSIT IN SEVEN CITIES—Prepared under the Direction of Theodore K. Long, Member of the Chicago City Council. Bulletin No. 3, Municipal Reference Library. Chicago, Ill.: Chicago Public Library. Paper; 6x9 in.; pp. 27.

A compilation of available data and general information on the rapid-transit facilities in New York, Chicago, Philadelphia, Boston, London, Paris and Berlin, under the heads of historical development, mileage, cost of sub-

ways and elevated roads, types of elevated construction, passenger traffic, motive power, rates of fare, sanitary conditions and noise, general observations.

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The Mechanics of Liquids

REVIEWED BY WINSLOW H. HERSCHEL*

TEXT-BOOK OF MECHANICS—By Louis A. Martin, Jr., Professor of Mechanics, Stevens Institute of Technology. Vol. V., Hydraulics. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd. Cloth; 5x8 in.; pp. xii + 223; 114 text figures. $1.50 net.

As the author points out, the science of hydraulics is based on "approximations, assumptions and the empirical results of experiments," and yet under such unfavorable circumstances he considers hydraulics as a branch of the pure science, mechanics, and remarks, "no attempt has been made to include in this text lists of the experimental constants of hydraulics." It is thus clear that the book is intended mainly to give mental training in the classroom. It is written in accordance with the plan of conquering a subject by successive attacks of increasing thoroughness, rather than by one prolonged assault. The former plan has the inherent disadvantage that the student, when he first takes up a subject in an elementary way, is in danger of acquiring wrong impressions, which can only be eradicated afterward with great difficulty. In the chapter on weirs, for example, several pages are devoted to Boussinesq's theory, and a few lines to the Francis formula, from which a student might easily infer that Boussinesq's formula is the more generally employed. Again, the outward-flow turbine is taken as the typical example, in spite of the fact that practically all modern turbines are of the inward-flow type. It is stated that the average value of the coefficient of discharge through a standard orifice is 0.60, and there is nothing to show the range of variation of this coefficient, or the comparative range of other coefficients, and yet it is just such points as this with which a practicing engineer must be acquainted. We must, therefore, regard the book, not as a handbook for hydraulic engineers, but as a text for colleges and technical schools on the mechanics of liquids, for which latter purpose it seems very well adapted.

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ADDENDUM, BEING THE FIVE CHAPTERS ON MODERN ROAD CONSTRUCTION Reprinted from "Asphalts" 1914 Road Edition—By T. Hugh Boorman. New York: The William T. Comstock Co., 23 Warren St. Paper; 7x10 in., pp. 169-191; illustrated. 25c. if sold separately; incorporated in new edition of book, price of which is $2.

The review of the original edition of this book (ENGINEERING NEWS, Feb. 18, 1909) stated that the volume consisted chiefly of quotations from various papers and reports. The Addendum seems to be largely of the same character. It consists of a preface to a "second edition," in this country; two pages and a half on asphalt macadam roads; a considerable chapter on cold-laid asphalt roads, or reading on "Westrumite" roads, Westrumite being a patented asphalt emulsion; a chapter on bituminous road surfaces with directions for applying various asphalt treatments, and two pages and a half on the use of asphalt blocks on roads.

The Addendum does not appear to contain much new matter and gives every appearance of being hastily compiled. For instance, the American Road Builders' Association is variously referred to as the National Road Makers Convention and the American Road Makers Convention. This may seem a small point, but to one who has done library research work such confusion and lack of accuracy are inexcusable.

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FARM STRUCTURES—By K. J. T. Ekblaw, Associate in Agricultural Engineering, University of Illinois. New York: The Macmillan Co. Cloth; 5x8 in.; pp. viii + 347; 159 illustrations. $1.75, net.

Now that agricultural engineering has attained a place in our state colleges and universities and has a national association of its own, it is not surprising to see a book on "Farm Structures" written by an engineering professor. The preface states that the book is intended to meet the needs of not only the teacher and student, but also those of the progressive farmer. Rightly used, it promises to serve this purpose.

The plan of this book is simple and logical. After reviewing building materials, from wood and steel to paint, glass and nails, there are a few pages on the location of farm buildings, a longer chapter on building construction and a few pages on estimating. The various kinds of farm buildings are next considered, beginning with granaries and machine sheds, continuing through various minor structures and ending with barns and the farm residence. Separate chapters are devoted to ventilation, lighting, heating, water-supply and, finally, plumbing and sewage disposal.

The author wisely refrains from going far into either the esthetic or sanitary phases of farm structures. Under sewage disposal, however, he goes farther than is necessary in setting forth underlying principles. And that is not all. He characterizes the septic tank as "the most scientific, perfect and efficient system of sewage disposal yet devised"—and describes and figures a most primitive rectangular tank. It is only fair to add that he makes it clear that the septic tank is only a preliminary means of treatment.

NEW PUBLICATIONS

[So far as possible the name of each publisher of books or pamphlets listed in these columns is given in each entry. If the book or pamphlet is for sale, and the price is known by the editor the price is stated in each entry. Where no price is given it does not necessarily follow that the book or pamphlet can be obtained without cost. Many, but not all, of the pamphlets, however, can be secured without cost, at least by inclosing postage. Persons who are in doubt as to the means to be pursued to obtain copies of the publications listed in these columns should apply for information to the stated publisher, or in case of books or papers privately printed, then to the author or other person indicated in the notice.]

THE CALCULUS FOR ENGINEERS—By Ewart S. Andrews, author of "Theory and Design of Structures"; Lecturer in Theory and Design of Structures at Goldsmiths' College, New Cross, and H. Bryon Heywood. [The Broadway Series of Engineering Handbooks, Vol. XIII.] London: Scott, Greenwood & Son. New York: D. Van Nostrand Co. Cloth; 4x7 in.; pp. xi + 269; 102 illustrations. 4 shillings, net.

COAL GAS RESIDUALS—By Frederick H. Wagner, M. Am. Soc. M. E., author of "Blast-Furnace Gases." New York and London: McGraw-Hill Book Co., Inc. Cloth; 6x9 in.; pp. xi + 179; 44 illustrations. $2, net.

CONCRETE ROADS AND PAVEMENTS—By E. S. Hanson, Editor "The Cement Era"; author "Cement Pipe and Tile." Revised edition. Chicago: The Cement Era Publishing Co. Cloth; 5x8 in.; pp. 338; illustrated. $1.50.

CONCRETE-STEEL CONSTRUCTION—Part I., Buildings: A Treatise Upon the Elementary Principles of Design and Execution of Reinforced Concrete Work in Buildings—By Henry T. Eddy, Professor of Mathematics and Mechanics, College of Engineering, and Dean of the Graduate School, Emeritus, University of Minnesota, Minneapolis, and C. A. P. Turner, M. Am. Soc. C. E., Consulting Engineer, Vancouver, Winnipeg, Minneapolis, New York, Chicago, etc. Minneapolis: The Authors. Cloth; 6x9 in.; pp. xv. + 438; 99 illustrations. $6, net.

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ELEMENTARY ELECTRICITY AND MAGNETISM: A Text-Book for Colleges and Technical Schools—By Wm. S. Franklin and Barry MacNutt. New York: The Macmillan Co. London: Macmillan & Co., Ltd. Cloth; 5x8 in.; pp. viii + 174; 152 illustrations. $1.25, net.

ENGINEERING WORKSHOP DRAWING: First Steps in Engineering Drawing—By Henry J. Spooner, M. Inst. Mech. E., A. M. Inst. C. E., Director and Professor of Mechanical and Civil Engineering, Polytechnic School of Engineering, Regent Street, London; author of "Machine Design, Construction and Drawing," "Machine Drawing and Design for Beginners," "Industrial Drawing and Geometry," "Motors and Motoring," etc., etc. New York and London: Longmans, Green & Co. Cardboard; 9x7 in.; pp. viii + 128; 618 text figures. 50c., net.

FOREIGN TRADEMARKS AND THE EXPORT TRADE of the United States in Central and South America; A Subject of Topical Interest to American Manufacturers in View of the European War—By Lawrence Langner, Singer Building, New York City. Paper; 5x7 in.; pp. 7. Copies sent free upon request.

GAS, GASOLINE AND OIL-ENGINES—By Gardner D. Hiscox, author of "Mechanical Movements," "Compressed Air," etc. Revised, enlarged and brought up to date by Victor W. Page, author of "The Modern Gasoline Automobile," etc. 21st Edition. New York: The Norman W. Henley Publishing Co. Cloth; 7x10 in.; pp. 640; 435 illustrations. $2.50, net.

MALLEABLE IRON SHOES FOR CONTINUOUS STAVE PIPE—The Malleable Iron Works, Marion, Ind. Cloth; 4x7 in.; pp. 135; illustrated. Sent free on request.

The bulk of this little book is devoted to a "Report on Continuous Stave Pipe," by Robert E. Horton, and to various hydraulic and other tables of use to designers of pipe lines.

MATHEMATICS FOR AGRICULTURAL STUDENTS—By Henry C. Wolff, Assistant Professor of Mathematics, University of Wisconsin. [Modern Mathematical Texts.] New York and London: McGraw-Hill Book Co., Inc. Cloth; 5x8 in.; pp. ix + 309; 127 illustrations. $1.50, net.

MINERAL RESOURCES OF ALASKA: Report on Progress of Investigations in 1913—By Alfred H. Brooks and Others. Washington, D. C.: U. S. Geological Survey. Bulletin Survey. Bulletin 592. Paper; 6x9 in.; pp. 413; illustrated.

MUNICIPAL CHARTERS: A Discussion of the Essentials of a City Charter with Forms or Models for Adoption—By Nathan Matthews, Mayor of Boston, 1891-1895; Chairman, Boston Finance Commission, 1907-1909; Lecturer on Municipal Government in Harvard University. Cambridge: Harvard University Press. Cloth; 6x9 in.; pp. vii + 210. $2.

OUR MINERAL RESERVES: How to Make America Industrially Independent—By George Otis Smith. Washington, D. C.: United States Geological Survey. Bulletin 599. Paper; 6x9 in.; pp. 48.

POLYPHASE CURRENTS—By Alfred Still, Assoc. M. Inst. C. E., M. I. E. E., M. A. I. E. E., author of "Alternating Currents and the Theory of Transformers" and "Overhead Electric Power Transmission." Second edition, revised. New York: The Macmillan Co. London: Whittaker & Co. Cloth; 5x8 net.; pp. xii + 300; 101 illustrations. $1.50, net.

POWER, HEATING AND VENTILATION: A Treatise for Designing and Constructing Engineers, Architects and Students. (In Three Parts, Each Complete in Itself)—By Charles L. Hubbard, Consulting Engineer. Part I., Steam Power Plants. Second edition, fully revised and reset. Pp. ix + 299; 183 illustrations. Part II., Heating and Ventilating Plants. Second edition, rewritten and reset. Pp. ix + 308; 207 illustrations. New York and London: McGraw-Hill Book Co., Inc. Cloth; 6x9 in. $2.50, each.

PRACTICAL HANDBOOK FOR BEET-SUGAR CHEMISTS: Rapid Methods of Technico-Chemical Analyses of the Products and By-Products and of Material Used in the Manufacture of Beet Sugar—By Werner Moeller-Krause, Sugar Chemist. Easton, Penn.: The Chemical Publishing Co. London: Williams & Norgate. Cloth; 6x9 in.; pp. viii + 132; 19 illustrations. $1.25.

PRINCIPLES AND PRACTICE OF ELECTRICAL ENGINEERING—By Alexander Gray, Assistant Professor of Electrical Engineering, McGill University, Montreal, Can.; author of "Electrical Machine Design." New York and London: McGraw-Hill Book Co., Inc. Cloth; 7x10 in.; pp. xxi + 391; 449 illustrations. $3, net.

THE REGULATION OF RIVERS—By J. L. Van Ornum, M. Am. Soc. C. E., Professor of Civil Engineering, Washington University, and Consulting Civil Engineer. New York and London: McGraw-Hill Book Co., Inc. Cloth; 6x9 in.; pp. x + 393; 99 illustrations. $4, net.

THE SCIENTIFIC PRICE MAKER AND PROFIT DETERMINER—Compiled and published by J. W. Conchar, 41 Park Row, New York City. In two volumes. Linen; 9x6 in.; pp. 170. Vol. I., $1. Vol. II., $2.

STATE CONTROL OVER WATER SUPPLY AND DRAINAGE CONDITIONS IN MARYLAND—By Robert B. Morse, Chief of Bureau of Sanitary Engineering, Maryland State Department of Health, 16 West Saratoga St., Baltimore, Md. [Reprinted from American Journal of Public Health, Vol. 4, No. 10.] Paper; 7x10 in.; pp. 6.

STATISTICS OF THE CLAY-WORKING INDUSTRIES IN THE UNITED STATES, 1913—By Jefferson Middleton. With notes of The Occurrence and Use of Flint Clay by J. H. Hance. [Being Part II. Mineral Resources of the United States, 1913.] Washington, D. C.: U. S. Geological Survey. Paper; 6x9 in.; pp. 104.

STEAM CHARTS, Also a Table of Theoretical Jet Velocities and the Corrections of Mercury Columns, with Fifty Illustrative Problems—By F. O. Ellenwood, M. Am. Soc. M. E., Assistant Professor of Heat Power Engineering, Cornell University. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd. Cloth; 7x10 in.; pp. iv + 91; illustrated. $1, net.

STEEL CONSTRUCTION: A Text and Reference Book Covering the Design of Steel Framework for Buildings—By Henry Jackson Burt, M. Am. Soc. C. E., Structural Engineer for Holabird & Roche, Architects. Chicago: American Technical Society, Drexel Ave. & 58th St. Flexible leather; 4x7 in.; pp. 372; 236 illustrations. $2.75.

STRENGTH OF MATERIALS—By H. E. Murdock, Irrigation Engineer, United States Department of Agriculture. Second edition, revised and enlarged. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd. Cloth; 5x8 in.; pp. xv + 352; 137 illustrations. $2, net.

STRENGTH OF MATERIALS—By Arthur Morley, M. I. Mech. E. Third edition. New York and London: Longmans, Green & Co. Cloth; 6x9 in.; pp. ix + 497; 244 illustrations. $2.50, net.

STRUCTURAL ENGINEERS' HANDBOOK: Data for the Design and Construction of Steel Bridges and Buildings—By Milo S. Ketchum, M. Am. Soc. C. E., Dean of the College of Engineering and Professor of Civil Engineering, University of Colorado. New York and London: McGraw-Hill Book Co., Inc. Flexible leather; 6x9 in.; pp. xv + 896; 400 illustrations. $5, net, postpaid.

SURGE TANK PROBLEMS: An Investigation of Surge Tank Regulation Determining by Graphical and Analytical Methods Proper Solutions of Problems Created by Long Pipe Lines—By Prof. Franz Prasil. Authorized Translation by E. R. Weinmann and D. R. Cooper. [Reprinted from "The Canadian Engineer," Vol. 27, 1914.] New York: E. R. Weinmann, 114 W. 80th St., New York City. Paper; 9x12 in.; pp. 27; 17 text figures. 50c.

SURVEYING MANUAL: Designed for the Use of First-Year Students in Surveying and Especially for the Use of Non-Civil Engineering Students—By Howard Chapin Ives, Professor of Railroad Engineering, Worcester Polytechnic Institute. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd. Leather; 4x7 in.; pp. viii + 296; 56 text figures and numerous plates. $2.25, net.

THEORY AND DESIGN OF STRUCTURES: A Text Book for the Use of Students, Draftsmen and Engineers Engaged in Constructional Work—By Ewart S. Andrews, Lecturer in Theory and Design of Structures at the Goldsmiths' College, New Cross. Third edition. New York: D. Van Nostrand Co. Cloth; 6x9 in.; pp. xii + 618; 289 illustrations. $3.50, net.

FURTHER PROBLEMS IN THE THEORY AND DESIGN OF STRUCTURES: An Advanced Text-Book for the Use of Students, Draftsmen and Engineers Engaged in Constructional Work—By Ewart S. Andrews, Lecturer in Theory and Design of Structures at the Goldsmiths' College, New Cross. New York: D. Van Nostrand Co. Cloth; 6x9 in.; pp. viii + 236; 99 illustrations. $2.50, net.

The original British editions of these books, which now bear an American imprint, were reviewed in our issue of Oct. 16, 1913.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, Vol. VI, 1913—New York: Office of the Secretary, Cooper Union, and D. Van Nostrand Co. Cloth; 6x9 in.; pp. 268; illustrated.

TRANSACTIONS OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS, Vol. XXVIII., Part I., January to June, 1914. Montreal: Office of the Secretary, 176 Mansfield St. Paper; 6x9 in.; pp. 385; illustrated.

UNITED STATES BUREAU OF MINES—Washington, D. C. Paper; 6x9 in.; illustrated.

United States Coals Available for Export Trade—By Van H. Manning. Bulletin 76. Pp. 15.

The Humidity of Mine Air, with Especial Reference to Coal Mines in Illinois—By R. Y. Williams. Bulletin 83. Pp. 69.

Production of Explosives in the United States During 1913—Compiled by Albert H. Fay. Technical paper 85. Pp. 15.

Quarry Accidents in the United States During 1913—Compiled by Albert H. Fay. Technical Paper 92. Pp. 76.

Hints on Coal-Mine Ventilation—By J. J. Rutledge. Miners' Circular 16. Pp. 22.

The Prevention of Accidents from Explosives in Metal Mining—By Edwin Higgins. Miners' Circular 19. Pp. 16.

UNITED STATES BUREAU OF STANDARDS—Washington, D. C. Paper; 7x10 in.; illustrated.

Observations on Finishing Temperatures and Properties of Rails. By G. K. Burgess, Physicist, J. J. Crowe, Assistant Physicist, H. S. Rawdon, Assistant Physicist, and R. G. Waltenberg, Laboratory Assistant. Technologic Paper No. 38. Pp. 63. 15c.

Units of Weight and Measure: Definitions and Tables of Equivalents. Circular No. 47. Pp. 68. 15c.

Measurements on Standards of Radiation in Absolute Value. By W. W. Coblentz, Associate Physicist. Scientific Paper No. 227. Pp. 14.

WAGES AND HOURS OF LABOR IN THE IRON AND STEEL INDUSTRY IN THE UNITED STATES, 1907 to 1912—Washington, D. C.: Bureau of Labor Statistics. Bulletin, Whole No. 151. Paper: 6x9 in.; pp. 550.

WATER SUPPLY PAPERS, U. S. GEOLOGICAL SURVEY—Washington, D. C. Paper; 6x9 in.

No. 332-C.: Surface Water Supply of the United States, 1912, Part XII. North Pacific Coast Drainage Basins. C. Lower Columbia River and Rogue, Umpqua and Siletz Rivers. By F. F. Henshaw and E. S. Fuller. Pp. 226.

No. 340-C.: Stream-Gaging Stations and Publications Relating to Water Resources, 1885-1913, Part III. Ohio River Basin. Compiled by B. D. Wood. Pp. 30.

No. 363: Quality of the Surface Waters of Oregon. By Walton Van Winkle. Pp. 137.

No. 364: Water Analyses from the Laboratory of the United States Geological Survey. Tabulated by F. W. Clarke, Chief Chemist. Pp. 40.